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TRANSACTIONS

OF THE

Illinois State Academy of Science

TWENTIETH ANNUAL MEETING

JOLIET, ILLINOIS

April 29 and April 30, 1927

VOLUME XX

Edited by Lyell J. Thomas, *Secretary*

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A. R. CROOK, *Librarian*

State Museum, Springfield, Ill.

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OFFICERS AND COMMITTEES FOR 1927-1928

President, H. J. VAN CLEAVE, University of Illinois, Urbana.
First Vice-President, C. FRANK PHIPPS, State Teacher's College, DeKalb.
Second Vice-President, R. M. Linkins, Illinois State Normal University, Normal, Illinois.
Secretary, LYELL J. THOMAS, University of Illinois, Urbana.
Treasurer, GEO. D. FULLER, University of Chicago, Chicago.
Librarian, A. R. CROOK, State Museum, Springfield.

The Council.

The Council is composed of the above officers and the last two retiring presidents.

Committee on Membership.

MRS. ELEANOR C. SMITH, Englewood High School, Chicago, Chairman.
W. P. HAYES, University of Illinois, Urbana.
R. G. BUZZARD, Illinois State Normal University, Normal.
V. A. LATHAM, 1644 Morse Ave., Chicago.

Committee on Affiliation.

H. R. GEAUQUE, Lombard College, Galesburg, Chairman.
F. H. COLYER, Southern Illinois State Teachers College, Carbondale.
L. E. HILDEBRAND, New Triar Township High School, Winnetka.
C. F. GRONEMAN, Elgin.

Committee on Ecological Survey.

E. L. STOVER, State Teachers College, Charleston, Chairman.
W. G. WATERMAN, Northwestern University, Evanston.
V. O. GRAHAM, University of Chicago, Chicago.
SAMUEL EDDY, University of Illinois, Urbana.
W. B. McDOUGALL, University of Illinois, Urbana.
R. B. MILLER, Dept. of Conservation, Springfield.
C. J. TELFORD, State Natural History Survey, Urbana.
RUTH MARSHALL, Rockford College, Rockford.
C. E. MONTGOMERY, State Teachers College, DeKalb.
L. W. TURNER, Blackburn College, Carlinville.
MARY M. STEAGALL, State Normal University, Carbondale.

Committee on Conservation.

H. C. COWLES, University of Chicago, Chicago, Chairman.
M. M. LEIGHTON, Chief, Geological Survey Division, Urbana.
W. N. CLUTE, Editor, American Botanist, Joliet.
W. H. HAAS, Northwestern University, Evanston.

Committee on Legislation and Finance.

FRED R. JELLIFF, Editor, Daily Republican Register, Galesburg, Chairman.
DON W. DEAL, Leland Office Building, Springfield.
EDWARD W. PAYNE, First Trust & Savings Bank, Springfield.
H. C. COWLES, University of Chicago, Chicago.
F. H. COLYER, Southern Illinois State Teachers College, Carbondale.

Committee on Publications.

THE PRESIDENT.
THE SECRETARY.
FRED R. JELLIFF, Editor Daily Republican Register, Galesburg.

Committee on High School Science and Clubs.

H. H. Radcliffe, 1346 W. Macon St., Decatur, Chairman.

Delegate to the American Association for the Advancement of Science.

W. P. FLINT, University of Illinois, Urbana.

Delegates to the Conservation Council of Chicago.

STUART WELLER, University of Chicago, Chicago.
V. O. GRAHAM, University of Chicago, Chicago.

PAST OFFICERS OF ILLINOIS STATE ACADEMY OF SCIENCE.

1907

(Organization meeting, Dec. 7, 1907, Springfield.)

Chairman, U. S. GRANT, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.

1908

(First annual meeting, Decatur, Feb. 22, 23, 1908.)

President, T. C. CHAMBERLAIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1909

(Second annual meeting, Springfield, Feb. 20, 1909.)

President, T. C. CHAMBERLAIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1910

(Third annual meeting, Urbana, Feb. 18, 19, 1910.)

President, S. A. FORBES, University of Illinois.
Vice-President, JOHN M. COULTER, University of Chicago.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1911

(Fourth annual meeting, Chicago, Feb. 17, 18, 1911.)

President, JOHN M. COULTER, University of Chicago.
Vice-President, R. O. GRAHAM, Illinois Wesleyan University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1912

(Fifth annual meeting, Bloomington, Feb. 23, 24, 1912.)

President, W. A. NOYES, University of Illinois.
Vice-President, J. C. UDDEN, University of Texas.
Secretary, FRANK C. BAKER, Chicago Academy of Science.
Treasurer, J. C. HESSLER, James Millikin University.

1913

(Sixth annual meeting, Peoria, Feb. 21, 22, 1913.)

President, HENRY CREW, Northwestern University.
Vice-President, A. R. CROOK, State Museum, Springfield.
Secretary, OTIS W. CALDWELL, University of Chicago.
Treasurer, J. C. HESSLER, James Millikin University.

PAST OFFICERS OF THE ACADEMY—Continued.

1914

(Seventh annual meeting, Evanston, Feb. 20, 21, 1914.)

President, FRANK W. DEWOLF, State Geological Survey, Urbana.
Vice-President, H. S. PEPOON, Lake View High School, Chicago.
Secretary, E. N. TRANSEAU, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. HESSLER, James Millikin University.

1915

(Eighth annual meeting, Springfield, Feb. 19, 20, 1915.)

President, A. R. CROOK, State Museum, Springfield.
Vice-President, U. S. GRANT, Northwestern University.
Secretary, E. N. TRANSEAU, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. HESSLER, James Millikin University.

1916

(Ninth annual meeting, Urbana, Feb. 18, 19, 1916.)

President, U. S. GRANT, Northwestern University.
Vice-President, E. W. WASHBURN, University of Illinois.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.

1917

(Tenth annual meeting, Galesburg, Feb. 23, 24, 1917.)

President, WILLIAM TRELEASE, University of Illinois.
Vice-President, H. E. GRIFFITH, Knox College, Galesburg.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.
Librarian, A. R. CROOK, State Museum, Springfield.

1918

(Eleventh annual meeting, Joliet, Feb. 22, 23, 1918.)

President, J. C. HESSLER, James Millikin University.
Vice-President, JAMES H. FERRISS, Joliet.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

1919

(Twelfth annual meeting, Jacksonville, March 21, 22, 1919.)

President, R. D. SALISBURY, University of Chicago.
Vice-President, ISABEL S. SMITH, Illinois College, Jacksonville.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

1920

(Thirteenth annual meeting, Danville, Feb. 20, 21, 1920.)

President, HENRY B. WARD, University of Illinois.
Vice-President, GEO. D. FULLER, University of Chicago.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, W. G. WATERMAN, Northwestern University.
Librarian, A. R. CROOK, State Museum, Springfield.

1921

(Fourteenth annual meeting, Carbondale, April 29, 30, 1921.)

President, HENRY C. COWLES, University of Chicago.
Vice-President, CHAS. T. KNIPP, University of Illinois.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, W. G. WATERMAN, Northwestern University.
Librarian, A. R. CROOK, State Museum, Springfield.

1922

(Fifteenth annual meeting, Rockford, April 27, 28, 29, 1922.)

President, CHAS. T. KNIPP, University of Illinois.
Vice-President, MISS RUTH MARSHALL, Rockford College, Rockford.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, WM. F. SCHULZ. University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1923

(Sixteenth annual meeting, Galesburg, May 3, 4, 5, 1923.)

President, W. S. BAYLEY, University of Illinois.
Vice-President, W. G. WATERMAN, Northwestern University.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, WM. F. SCHULZ, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1924

(Seventeenth annual meeting, Elgin, May 1, 2, 3, 1924.)

President, W. G. WATERMAN, Northwestern University.
Vice-President, H. J. VAN CLEAVE, University of Illinois.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, WM. F. SCHULZ, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1925

(Eighteenth annual meeting, Springfield, Feb. 20, 21, 1925.)

President, DR. W. G. BAIN, St. John's Hospital, Springfield.
First Vice-President, C. H. SMITH, Hyde Park High School, Chicago.
Second Vice-President, R. C. LANPHIER, Sangamo Electric Co., Springfield.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, W. B. MCDOUGALL, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1926

(Nineteenth annual meeting, Harrisburg, April 30, May 1, 1926.)

President, STUART WELLER, University of Chicago, Chicago.
First Vice-President, MRS. ELEANOR C. SMITH, Englewood High School, Chicago.
Second Vice-President, CLARENCE BONNELL, Township High School, Harrisburg.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, W. B. MCDOUGALL, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1927

(Twentieth annual meeting, Joliet, April 29, 30, 1927.)

President, WILLARD N. CLUTE, Editor, American Botanist, Joliet.
First Vice-President, MARY M. STEAGALL, Southern Illinois State Teacher's College, Carbondale.
Second Vice-President, C. E. SPICER, Joliet High School, Joliet.
Secretary, LYELL J. THOMAS, University of Illinois, Urbana.
Treasurer, W. B. MCDOUGALL, University of Illinois, Urbana.
Librarian, A. R. CROOK, State Museum, Springfield.

ILLINOIS STATE ACADEMY OF SCIENCE

Office of the Secretary

University of Illinois, Urbana, Illinois.

Council Meeting, Botany Department, University of Chicago, June 17, 1926.

All officers of the Academy, except the Librarian and the immediate predecessor of the retiring president were present. President W. N. Clute presided.

The Council by vote recommended the following changes in the Constitution that they may be acted upon at the Annual Meeting: Article III, last paragraph, insert after 'be approved', the words *by the Council and;* after 'membership', the words, *at the Annual Meeting.* Article V, insert in the first paragraph after 'President', the words, *First Vice President, Second Vice President.*

By vote the Council recommended the following addition to the by-laws, to be acted on at the Annual Meeting: By-law XI. Except by invitation of the Council, no paper may be accepted for the program unless the author is a member of the Academy or an applicant for membership and no paper will be published unless the M. S. be handed in to the secretary within thirty days after the Annual Meeting.

The place for the Annual Meeting was discussed and invitations for the 1927 meeting considered. By vote it was decided that the Academy meet in Joliet. The Council instructed the Secretary to transmit a letter of appreciation to President Felmley of Normal for the splendid attitude towards the Academy and for the letters of invitation to meet in Bloomington and Normal and to state that the Academy contemplates meeting there in 1928.

Moved and carried that the date of the Joliet meeting be held on the week of the Chicago school spring vacation.

Mr. C. E. Spicer was elected Second Vice President.

The following committees were appointed:

Committee on Ecological Survey—W. G. Waterman, Chairman; G. D. Fuller; W. B. McDougall; Ruth Marshall; E. L. Stover; C. E. Montgomery; C. Bonnell; Mary M. Steagall; Samuel Eddy, and C. J. Telford.

Committee on Conservation—H. C. Cowles, chairman; M. M. Leighton; W. N. Clute; W. H. Haas.

Committee on High School Science and Clubs—E. R. Downing, Chairman. By vote the chairman was empowered to select other members of his committee.

Committee on Legislation and Finance—Don W. Deal, Chairman; Edward Payne; F. H. Colyer; Fred Jelliff; H. C. Cowles.

Moved and carried that the Chairman of the Committee on Ecological Survey be authorized to print 500 copies of the report for the use of the Committee.

The Secretary was appointed by vote as delegate to the American Association for the Advancement of Science with the power to appoint an alternate if unable to attend.

W. N. Clute and Stuart Weller were appointed delegates to the Conservation Council at Chicago by vote of the Council.

The Treasurer presented thirteen names to be passed on for membership. Moved and carried that the Council approve the names of these candidates for membership that they may be presented at the next meeting of the Academy.

Meeting adjourned.

LYELL J. THOMAS, *Secretary.*

Council Meeting, Joliet, December 11, 1926.

The members of the Council were introduced to the hospitality of Joliet by a luncheon at the Hotel Woodruff, given by President and Mrs. Clute. The two past presidents were unable to attend. By invitation past secretary Phipps attended the council meeting.

Following the luncheon the meeting was called to order by President Clute. The preliminary report of the Treasurer was given and accepted:

Cash balance April 3, 1926	$ 410.17
Receipts May 1 to December 10, 1926	650.22
Total	$1,060.39
Expenditures May 1, to December 11, 1926	551.37
Balance December 11, 1926	$ 509.02

The Treasurer also presented eight names which were approved by the Council for membership.

The following changes were recommended in the Constitution to be acted on at the Annual meeting:

(1) Amend by-law IX by adding the sentence, "The Secretary shall receive $150.00 to be paid semiannually."

(2) Amend by-law VIII by adding the sentences, "No paper shall be published unless the manuscript be handed in to the Secretary within thirty days after the Annual meeting. All papers are limited to twenty pages, additional pages are to be paid for by the author." Proposed by-law XI is to be made an ammendment to by-law VIII. See Council minutes of June 17, 1926.

(3) Insert in the paragraph *Life Members* etc. Article III, at the end of the first sentence the words, "at one time or complete payments before the annual meeting of 1928." Also add the sentence, "The dues from such a source are to be placed as a permanent fund and only the income is to be used." The paragraph will then read—"*Life members* shall be national or local members who have paid fees to the Academy to the amount of twenty dollars at one time or complete payments before the annual meeting of 1928. The dues from this source are to be placed as a permanent fund and only the income is to be used."

The Council authorized the Secretary to employ extra clerical help to ascertain the date on which each member joined the Academy and to print this after their favorite science in the list of members in the Transactions. The Secretary was also authorized to call in by wire if necessary all proof held up by authors so as not to delay the publication of the Transactions.

Dr. Mary M. Steagall was appointed alternate delegate to the A. A. A. S. meeting at Philadelphia.

It was voted by the Council to accept with very cordial thanks a gift to the Academy by Dr. W. S. Moffat of Wheaton, Illinois, consisting of a herbarium of flowering plants, some eight thousand sheets. These are now in the possession of Dr. A. R. Crook, the custodian of Academy property. The final acceptance of the gift is left for the action of the members at the Annual meeting.

By vote the following were appointed as a Program Committee for the Annual Meeting: President Clute, Mr. C. E. Spicer, and the Secretary. Plans for the Annual meeting were discussed with Mr. C. E. Spicer, chairman of the local committee of arrangements.

The date of the Joliet Meeting was set, by vote, for Friday, April 29, and Saturday, April 30, 1927. The Council approved a business meeting and general session for Friday forenoon; the afternoon to be given over to the section meetings. A popular lecture is to be given that evening. Field excursions are to be reserved for Saturday and Sunday for such of those who might care to stay.

The following names were submitted by the President for chairmen of the Sections at the 1927 Annual Meeting at Joliet:

Dr. H. S. Pepoon, Lake View High School, Chicago, chairman, Biology and Agriculture.

Professor Wm. C. Gould, State Teachers College, DeKalb, chairman, Geography and Geology.

Dr. G. D. Higginson, University of Illinois, Urbana, chairman, Psychology and Education.

Professor H. H. Radcliffe, 1346 W. Macon Street, Decatur, chairman, High School Science and Clubs.

Chairmen for the sections of Chemistry and Physics, and Medicine and Public Health are yet to be appointed.

Meeting adjourned.

L. J. THOMAS, *Secretary.*

Council Meeting, Joliet, April 29, 1927.

The Council met with the Local Committee of Arrangements and members of Affiliated Societies.

The Council by vote recommended that hereafter the approval of recommendations for membership be left to the Committee on Membership.

The continuation of the Committees on Ecological Survey, Conservation, and on High School Science and Clubs was discussed. Although the State Board has largely taken over the work of these Committees on Ecological Survey and the Committees on Conservation, it was considered wise to continue them so that they would be available to act in an emergency.

The Council recommended by vote that a uniform bill be adopted for the use of the Secretary and Treasurer.

The purchase of an Addressing Machine was discussed, and the Council recommended by vote that the decisions in such matters be left to the discretion of the Secretary, Treasurer, and President.

Meeting adjourned.

State Academy of Science Business Meeting, 11:00 A. M., Joliet, Ill., April 29, 1927.

The meeting was called to order by President Clute.

The Treasurer's report was first called for, and the following written report was submitted:

TREASURER'S REPORT, APRIL 29, 1927

RECEIPTS

Balance on hand April 30, 1926	$ 410.17	
Annual dues collected	544.15	
Life membership fees received	19.00	
A. A. A. S. dues received	10.00	
Received for reprints	199.82	
Received from sale of Transactions	111.00	
Received as annual grant from A. A. A. S.	162.50	
Total receipts		$1,456.64

DISBURSEMENTS

Printer's bill for reprints	$ 197.59	
To postage for mailing Transactions	64.03	
A. A. A. S. dues for new members	10.00	
Expenses of Secretary's Office	291.24	
Expenses of Treasurer's Office	74.99	
Expenses of Council members	24.09	
Expenses of Membership committee	22.81	
Secretary's Salary	150.00	
		$834.75
Balance on hand April 29, 1927		$621.89

W. B. McDOUGALL, *Treasurer.*

The Secretary reported that Vol. 19, Transactions of the Harrisburg meeting, had been sent out to all members, and that the reprints ordered from this volume by authors had arrived and would be distributed in the near future.

The Librarian submitted the following written report:

Librarian's Report.

A larger number of the copies of the Transactions published by the Academy, which are for sale, have been sold this year than at any time previous.

From this sale, $111 have been turned over to the Treasurer, and $24 are still in the process of collection, making a total of $135.00 worth sold this year.

Of the following volumes, we have a few copies in excess of five hundred, and these may still be obtained by new members by sending postage: II, III, VII, IX and X. Of Volume VI, but 208 remain, and of Volume I, we have but about 30 remaining.

Respectfully submitted,

A. R. CROOK, *Librarian.*

The Affiliation Committee submitted the following report: H. R. Geauque, Chairman, reported that an Affiliation Committee should be continued for more than one year in order to be of service to the Academy.

No report was turned in by the Ecological Survey Committee since the work of this committee has largely been taken over by the State, however, it was suggested that the Committee be retained to act in any emergency.

The Membership Committee did not turn in a formal report at this time.

The High School Science and Clubs Committee, H. H. Radcliffe, Chairman, reported as follows:

The meeting was unusually interesting, and it is a compliment to all who presented papers to be able to say that there was not a single "dry" moment, and that every one was followed by a lively discussion. Some who came to hear just one paper remained to the close. Some remarked that they had been attending the meetings for many years, but never one so interesting.

Personally I thought before the meeting it seemed useless to undertake to keep up the section, but the enthusiasm of this meeting was ample repay for the effort.

The Conservation Committee reported as follows:

One of the chief events of the year has been the appointment of Mr. R. B. Miller, one of our Academy members, as State Forester, under the new Department of Conservation. Mr. Miller has begun his service, and is inaugurating the purchase of lands for state forestry purposes. It is important that each legislative session make appropriations to further the forestry work of the state. Your committee was active in furthering Mr. Miller's appointment.

Another big event of the year is the continued development of the upper Mississippi wild life refuge under the able superintendency of W. T. Cox, of Winona, Minn. This refuge involves the Mississippi frontage of Illinois, north of Rock Island.

Little progress has been made or is in sight in regard to State Parks. Senator Hicks has offered a bill for the establishment of a Park to include the white pine woods of Ogle Co. The tax situation in the State is unfavorable to an immediate comprehensive State Park program.

The committee on Legislation at this meeting is presenting various matters touching on stream pollution, forestry, and other conservation matters.

Respectfully submitted,

H. C. COWLES, *Chairman.*

The Committee on Legislation and Finance reported that there are pending in the Legislature several bills of interest to the State Academy: The most important of these is Senate Bill No. 245, introduced by Senator W. S. Jewell of Lewistown on March 29, and referred to the committee on Canals and Waterways. This is an act to establish a Sanitary Water Board and to control, prevent, and abate objectionable pollution of the streams, lakes, ponds, and other water courses and surface bodies of water in the State. The Board consists of the Directors of the Departments of Agriculture, Public Health, Conservation, Purchases and Construction, who are to serve without addi-

tional compensation. An advisory council to the Sanitary Water Board and without salary is provided for.

A similar bill presented to the last Legislature passed the House, but was defeated in the Senate. Senator Jewell writes that there is considerable opposition to the measure, and it will need all the backing that this organization can give it.

It is recommended that each member of the Academy communicate with the Legislator from his district and urge them to give this bill their support.

It is further instructed that the Secretary respectfully request the two Illinois Houses to take favorable action on this bill.

Correspondence has been had on the subject of the State providing nurseries of our forest trees, from which land owners may procure trees for re-forestration purposes. Thirty-three states now maintain such nurseries. We have been informed by the State Forester that it is the purpose of the Department of Conservation to establish such nurseries, provided the Legislature approves of the appropriation asked by the Department.

It is recommended that the State Academy of Science approve the establishment of such nurseries, and that this action be communicated to the two Houses.

There is also pending in the House an act in relation to the acquisition and establishment of a State wide system of fishing and hunting grounds. The Department of Conservation would have charge of this system.

The Committee has also interested itself in the matter of procuring an appropriation for the printing of Transactions of the Illinois State Academy of Science. It is trusted that the officials of the organization have also had this in mind.

Respectfully submitted,

DR. H. C. COWLES, *Chairman.*

The following changes in the Constitution, which had been approved of by the Council, were presented by the Secretary and passed by the members: Article V, insert in the first paragraph after "president," the words *First-Vice President, Second Vice-President.*

Amend By-law VIII by adding the sentences, *no paper shall be published unless the manuscript be handed to the Secretary within thirty days after the Annual Meeting. All papers are limited to twenty pages, additional pages are to be paid for by the author. Except by invitation of the Council, no paper may be accepted for the program unless the author is a member of the Academy or an applicant for membership.*

Insert in the paragraph Life Members, etc., Article III, at the end of the first sentence, the words, *at one time or complete payments before the annual meeting of 1928.* Also, add the sentence, *The dues from such a source are to be placed as a permanent fund and only the income is to be used.* The paragraph will then read—"Life members shall be national or local members who have paid fees to the Academy to the amount of twenty dollars at one time or complete payments before the annual meeting of 1928. The dues from such a source are to be placed as a permanent fund and only the income is to be used."

Adjournment to meet at 5:00 P. M.

Final Business Meeting, April 29, 5:00 P. M.

The Auditing Committee reported as follows: We, the committee appointed to audit the report of the Treasurer of the Illinois State Academy of Science have examined the accounts, have verified the entries of expenditures against approved vouchers or cancelled checks. We find the balance of $621.89, as reported on April 29, 1927, correct.

H. J. VAN CLEAVE,
FRANK H. COLYER,
J. C. HESSLER.
Committee.

The Nominating Committee reported the following candidates for offices: For President, H. J. Van Cleave, Urbana; First Vice-President, C. Frank Phipps, DeKalb; Treasurer, Geo. D. Fuller, Chicago; Secretary, L. J. Thomas, Urbana. The Secretary was instructed to cast a unanimous ballot for the above candidates.

Report of the Section Chairmen is as follows: No chairmen were elected by the following Sections for the

ensuing year: Geology and Geography, Psychology and Education. The Chairman for the Chemistry and Physics Section is Dr. Fred H. Currens, Western Illinois State Teachers College, Macomb, Ill.; for the Medicine and Public Health Section, Dr. V. A. Latham, 1644 Morse Ave., Rogers Park, Chicago was elected, and the chairman for the High School Science Section is H. H. Radcliffe, Principal of Night School, 1346 W. Macon St., Decatur, Illinois. Prof. Wm. P. Hayes, Dept. of Entomology, University of Illinois, is appointed Chairman of the Section of Biology and Agriculture.

Due to the absence of the Chairman of the Membership Committee no formal report was given for the year, however, the total additions, withdrawals, and deaths for the year are as follows: 22 withdrawals, 4 deaths, 62 new members, giving a net gain for the year of 42.

The Committee on Resolutions made the following report:

I. *Resolved,* That we express our deep appreciation for the hospitality shown the State Academy during its sessions in Joliet, which has contributed greatly to our pleasure and comfort. We are especially grateful to the local committee on arrangements; to the Joliet Township Board of Education for the use of its beautiful and commodius High School building, and for the appetizing luncheon served at noon; to the High School Cadets for their courtesies; to those making such kind provisions for the field trips; to the press of the city for its favors, and, to all organizations of the city who have contributed to the success of the sessions, altogether making the meeting one of the most enjoyable in the history of the State Academy.

II. *Resolved,* That the Illinois State Academy of Science re-affirm its declaration of former years against the continued pollution of the streams, lakes and other bodies of water with sewage and factory waste, and again call the attention of the members to the recommendations of the Committee on Legislation pertaining to this subject; and, also, that we approve the recommendations regarding re-forestration, and the suggestions of the Committee on Conservation.

III. The Academy of Science accepts with much pleasure the generous gift of the Herbarium from Dr. and Mrs. Wm. S. Moffatt, now of California. We tender our grateful thanks to the donors.

IV. The Academy of Science wishes to record on the minutes its regrets and sympathy to the family of Dr. Erwin Smith, who recently died, and who has rendered such conspicuous service to the progress of plant pathology, and, also, its relation to cancer in the Department of Agriculture, Washington D. C., and to all the scientific workers of the world.

Also, the Academy expresses its regret over the death of Dr. Sargent of Howard University, and foremost man in the interest of culture. Dr. Sargent was the creator of the Arnold Arboretum. We wish to take this means of spreading recognition of his work on the minutes of the Academy of Science. It is with sorrow and regret that the Committee reports the deaths of James H. Ferris of Joliet; Charles H. Smith of Chicago, F. Kohl of Centralia, Dr. O. B. Thompson of Carbondale, and Frank M. Woodruff of Chicago.

FRED R. JELLIFF,
V. A. LATHAM,
C. F. PHIPPS,
Committee.

The Academy was informed that both Bloomington-Normal, and Decatur had extended invitations for the 1928 annual meeting. The council will decide at an early date which to accept.

Meeting adjourned.

L. J. THOMAS, *Secretary.*

PAPERS IN GENERAL SESSION, JOLIET.

ON POPULARIZING SCIENCE.

WILLARD N. CLUTE, JOLIET, ILLINOIS.

The Constitution of the Illinois State Academy of Science provides that it shall be one of the duties of the President to prepare an address to be delivered before the Academy at the Annual Meeting. This provision undoubtedly contemplates an eminently scientific paper on some subject of absorbing interest but since no penalties are provided for a failure to comply with this regulation, I feel that I may safely disregard the specifications in the present instance and spend a few minutes in discussing a matter which, though not strictly scientific, is, in large measure, a subject that concerns both the scientist and the public.

My thesis is that not enough is being done by the scientist to popularize science and the study of science. Of so-called popular science there is no end, but most of this is mere talk about science; information derived from others and passed on to third persons. Real students of science are rare. Every teacher knows how lamentably few of his students continue the subject after the course is finished unless, perchance, the information so secured may be used later in making a living. What is needed is to arouse an interest in, and a love for, scientific study at first hand.

The scientist carrying on investigations which he feels are sufficiently valuable in themselves, rarely feels called upon to make his problems intelligible to the general public. Frequently he has not the time or the opportunity even if he has the inclination to do so. In return the public is prone to think that science is the province of the super-individual and quite beyond ordinary comprehension. Though an occasional investigator may be attracted to scientific things, the majority do not know where or how to begin. Much as they would like to understand and enjoy, they can only wonder and speculate.

The stirring of the scientific instinct may often be observed in the collecting of shells, minerals, plants, bird's eggs, and even buttons and tobacco tags. This interest can, and should be, directed into useful channels before its pos-

sessor concludes that the only worth-while collection is a collection of the "coin of the realm." When I recall that one of our foremost conchologists was a grown man before he knew one shell from another, and that a certain excellent botanist was more than fifty years old before he began his studies, I can imagine that many an enthusiastic student has been lost to science for want of somebody to set his feet in the right path.

Nor is the attempt to spread a wider interest in science of benefit only to the beginner. A better informed public may be depended on to aid even the advanced scientist in his work. In all problems that depend on the securing of data from many and widely separated observers the co-operation of the public is invaluable. Such problems as the range of species, the migration of birds, the spread of the boll weevil, of the chestnut blight, and the corn borer, as well as extended phenological investigations must depend on help of this kind for solution. And if such considerations are not convincing, there is still the matter of funds for salaries and research, which aid, coming largely from an appreciative public, is likely to be proportionate to the interest aroused.

Practically all the advances toward a healthier and happier existence have come through the efforts and discoveries of the scientist but without support from an intelligent public such advances may be greatly delayed or even frustrated. We have not yet passed the stage in which our streams are polluted, our forests mismanaged, our timber wasted, and the range destroyed. Floods thus become increasingly destructive, disease may spread unchecked, and beautiful scenery, the heritage of every citizen, obscured by ugly bill-boards, or defaced by hot-dog stands and filling stations.

Unless one makes a special inquiry into the matter it is impossible to realize how abysmally ignorant of the fundamentals of science the average individual is. As a matter of fact, he rarely distinguishes between the real scientist and the adherents of a sect whose doctrines, however, worthy of admiration they may be, are, of all things, the least scientific. The public's knowledge of science is likely to be of the kind referred to by that homely philosopher,

Josh Billings when he wrote: "It is better to know less than to know so much that ain't so."

So far as science is concerned, a large part of the public is still living in the Dark Ages. In spite of St. Paul's adjuration to "Prove all things and hold fast that which is good" it inclines to the other extreme and giving up its natural right to think, listens to the voice of "Authority" —that voice which, according to H. G. Wells, made itself so clearly heard in the early centuries of our era as to obfuscate practically all knowledge and intelligence for nearly a thousand years.

It is probably no exaggeration to state that fully half of the people still believe in miracles; not the miracles of Bible times, but present day miracles in which some natural law is contravened on special occasions or for special purposes. How else can one explain the custom of wearing a string of amber beads for the cure of goiter, the tying of a red thread around the neck to stop nosebleed or the various incantations for charming away warts?

It is true that we have pretty generally abandoned a belief in the power of fern-seed to make one invisible, or in the mandrake which was reputed to emit such shrieks on being pulled from the ground as to make everybody within hearing, mad. But Paracelsus' "Doctrine of Signatures" still has its votaries and in out-of-the-way places people still plant in the sign of the moon, believe in the power of a forked stick to locate underground streams and buried treasure, and assume that it is necessary to mutilate a crow's tongue in order to make him talk.

Even in less remote districts, people hold a respectful attitude toward ghosts, witches, fortune-tellers, charms, signs, mascots, and the revelations of the ouijaboard. And still more scientific folk have been known to carry a horse-chestnut or a small potato in the pocket as a charm against rheumatism and for all I know may still place absolute faith in a small bag of asafetida worn around the neck as a protection from any kind of an epidemic. We smile at the Hopi Indian's snake-dance for the purpose of making it rain and then raise a fund for some pretentious aviator to bombard the clouds on our own account.

The public is not entirely to blame for its beliefs, for it has been somewhat unfortunate in its guides and teach-

ers. The modern agency from which most of us derive an idea of matters outside of our immediate cognizance—the newspaper—is, in matters of science, about of the time of Aristotle. Newspaper science is "fearfully and wonderfully made." Usually it is incorrect and frequently wilfully misleading. The callow reporter, an entire stranger to scientific method, and often others not so callow, is impressed by the marvellous or what appears to him to be the marvellous. Not satisfied with things as they are, he must ever dress them up in a garb of "human interest." Thus it happens that he places great stress on such horrendous things as man-eating trees, plants that have the power to foretell earthquakes, plants that cough, or get angry, or exhibit indications of cerebration that none but the higher animals possess.

It has often been said that if the daily press devoted as much space to science as it now devotes to sports, the scientist and all his works would come into their own—but not if the cub reporter conducted the science page. Though science should become as popular as short skirts and bobbed hair, it would still be the kind of science which we enclose in quotation marks so long as it concerns a fairyland in which the birds, flowers, trees and wind hold converse and the universe is pictured as an elderly dame called nature. It is perhaps too much to expect that the newspapers will do much for science of their own accord. The subject lacks the spectacular, offers no very definite field for exploitation, and does not contribute to the gate receipts.

For a time it was hoped that the introduction of science into high school curricula would largely increase the interest in things scientific, but this does not appear to be so at least in the case of the "natural sciences." The restriction on time and material necessitated by class-room study, the emphasis placed on drawing and note-book making, the disassociation of the objects studied from their natural environment, the use of pickled and preserved specimens and the insistence on the ability of the student to repeat the words of the text have all served to dampen enthusiasm and curb curiosity. It is no longer fashionable to know the animals and plants in their haunts. The science of biology has pressed on into new fields and the young student of the

present frequently has a better knowledge of his specimen's interior than he does of its exterior.

Doubtless the scientist will concede without argument, most of the statements here made, but he may ask how matters can be remedied. To such a question I must answer that I do not know, else I would be talking of cures instead of symptoms. After trying to popularize science on my own account for more than a quarter of a century without very encouraging results, I hesitate even to make suggestions. I am convinced, however, that meetings such as these may be made to go a long way in arousing enthusiasm in the beginner. To accomplish this, it seems to me, we shall have to put greater efforts on making our scientific papers intelligible. Perhaps we shall have to divide the time between papers designed for the edification of the advanced scientist and others intended to attract the non-scientific, but if we do, it will be well to remember that we cannot make these latter too elementary.

In order to make better progress, the scientist, no matter what his field, will have to take the public more into his confidence. Even at the risk of seeming to court the limelight, he will be obliged to crowd the science reporter out of the local papers—or reform him. Publicity such as that which made the little town of Dayton famous is not desirable, but propaganda that will establish science in its rightful position before the public, is necessary. Not until a majority of the people in a given region attend the meetings of the Academy and similar societies will science have reached the prominence to which it is warranted in aspiring.

In recent years, the working people have been favored with greatly shortened hours of labor and thus an increased number of people have time to take up scientific studies. We should not let the auto, the radio, the movies, and sports, engross, entirely, the attention of this new aggregation of prospective investigators.

Nor does the desire to interest these and others in our work spring from any hope on the part of the scientist for additional honors or greater veneration. It is prompted solely by a sincere desire to bring to the masses a more worthy way of spending their leisure, to give them a deeper appreciation of the world we live in, and by advancing science promote a safer, saner, and more satisfactory existence.

GEOLOGY OF THE JOLIET DISTRICT.*

D. J. FISHER, UNIVERSITY OF CHICAGO.

Geology is a science which is of value to man from three points of view: (1) the economic, for it serves as an aid to the discovery and efficient recovery of valuable mineral resources, (2) the scientific, and (3) the cultural and philosophical. It is the last of these which is emphasized in this paper. In our every-day life it is a source of considerable satisfaction to have a distinct knowledge of the part that we in our little span as individuals are playing in the much greater scheme of the story of the earth. The treatment is historical, and leads up to the present; the story of the future can be interpreted from the story of the past.

No one limited area serves the geologist in deciphering the whole earth history; each district has its gaps or "lost intervals" which must be filled in by information from other places. The geologist in his search for the truth may be likened to the scholar of ancient history who searches among the ruins of Egypt for records of its past; but with the decline of Egyptian progress, the story and search are transferred to Greece, and then to Rome.

The rocks are the records used by the geologist. Their physical characteristics and relationships, as well as any remains of organisms or fossils found within them, serve as the "dead language" from which his story must be deciphered.

The rocks known in the Joliet area are all sedimentary in origin; that is, they were deposited by cool water, wind, and ice. They were laid down, one on top of the other, in orderly sequence. Thus the older rocks lie beneath the younger rocks—just like a house in which the oldest or lowest story is always the one built first; no one ever heard of building a house by first putting up the roof in the air, and then constructing the walls to support the roof.

The rocks of the Joliet area are of two types—consolidated and unconsolidated. In the main, the former or bed rocks were deposited from waters and the latter or mantle

rocks were laid down by great masses of ice or glaciers which overrode the area relatively recently. Waters and winds were also important agents in the deposition of the incoherent material.

Imagine a cut straight down into the ground to a depth of 1000 feet below sea level along a line extending east from a point about five miles northeast of Morris through and beyond Elwood about two miles and thence N. 20° E. through a point 4 miles east of Joliet. (Fig. 1) An exaggerated diagram of the slice of earth revealed by the cut would look somewhat like figure 3. Figure 2 shows the details of the mantle rock deposits. Its vertical scale is larger than that of figure 3 in the proportion of 50: 13; i. e. the vertical scale of figure 3 is exaggerated 13 times, and of figure 2, 50 times. The horizontal scales are the same for both diagrams.

Figure 3 shows the various consolidated formations known to underlie the area. In the main these were laid down in relatively shallow seas that covered the district at different periods millions of years ago. Note the position of the Kankakee formation which outcrops in the southwest corner of the city of Joliet. A slab taken from this formation on Rock Run five miles west of Joliet is made up of a mass of petrified shells of animals somewhat resembling clams. They are not clams, however, but brachiopods, and are of a type that could live only in salt seawater. It is thus known that this formation must have been deposited in a sea that covered the area long ago.

The several formations shown in figure 3 in the main originated in this same fashion. What the lowest formation (Cambrian) rests on in this area is unknown, as no well near Joliet has been drilled through it, though a well at Bensenville (30 miles north of Joliet) penetrated it nearly 1000 feet.

The contact between the Lower and Middle Ordovician strata at the base of the St. Peter sandstone is particularly uneven, though none of the contacts shown is smooth. Following the deposition of the Prairie du Chien series a relative rise of the submerged land surface caused the withdrawal of the sea, and for some time the area was subjected to the erosive action of ancient streams and

winds. Later when the St. Peter sands were laid down, they filled old valleys. As a result of the rough surface developed during the "lost interval" between the times of deposition of the Prairie du Chien and St. Peter formations the thicknesses of the two vary notably in short distances. All the other contacts indicate "lost intervals" but during none was so uneven a surface developed, though the time interval may have been as long as or longer than that between Prairie du Chien and St. Peter depositions.

Following the deposition of the Niagaran dolomite all the older strata were tilted down in an easterly direction, as shown in figure 3, but the tilting was greater than the present dip of the rocks indicates.

At the extreme left edge of the diagram, Pennsylvanian rocks appear. These are much younger than the Niagaran dolomite; between these two is a great gap. The Pennsylvanian strata (or Coal Measures) dip to the west. They were presumably nearly horizontal when laid down; therefore it is obvious that following their deposition the region suffered a second tilt in a direction more or less opposite to the first one. This second tilt was smaller than the first one, but it was very important, for, without it Illinois would not have her present great coal resources.

The great "missing link" of the geologic section of the Joliet area is found in the essential absence of deposits younger than the Pennsylvanian and older than the glacial mantle rocks. For example, during this interval many thousands of feet of strata were laid down on the land and in a series of seas that covered the site of the present Rocky Mountains. Later these mountains were gradually formed by a succession of tremendous upheavals of the earth; still later much of the rock deposited was removed by erosive agents. The great niche of the Grand Canyon of the Colorado hardly represents a tithe of the rock thus removed; some of the debris collected in this fashion has accumulated at the head of the Gulf of California, partly filling in the gulf and adding thousands of square miles to the land area there. Equally important physical changes were taking place elsewhere and could be cited were the space available.

What happened in the Joliet area during these lost eras? All evidence points to the fact that erosive agents

slowly removing the solid rock were moderately active. The result was the planation of the tilted formations which was completed during this interval. Much of the Niagaran dolomite and other soluble rock was removed by means of the dissolving action of water. The relatively insoluble siliceous materials in the dolomite tended to be left, however, and remnants of such materials may still be seen as bluish clay in old solution cavities. Near the southwest corner of the quarry of the National Stone Company half a mile south of Joliet, one of these cavities has been exposed which, according to Mr. George Langford of Joliet, formerly contained blue clay. Just west of the corner of Clinton and Scott Streets, only 1200 feet west of the Joliet High School building, an excavation showed a similar pocket filled with beautifully laminated bluish clay; the curved laminae lay parallel the bottom of the bowl-shaped cavity.

But these deposits are a most meagre record from which to piece the history of this long interval. Of the dinosaurs and other life forms that flourished here during different portions of this time, not so much as a footprint remains. Truly "the mighty have fallen".

* * *

The mantle rock of the area consists of a heterogeneous mass whose origin for a long time puzzled the early geologists. A characteristic exposure of this material, which is found both on hills and in valleys, would show pebbles and boulders surrounded by yellow clay. The boulders are of rock not belonging to any formation outcropping within 200 to 300 miles of Joliet. What could have brought them here? Were they blown south by the wind, or carried by some stream long since extinct? The only feasible transporting agent is moving ice. The conception that a great ice-sheet formerly covered this district is a stupendous one. Picture a mass of ice, probably half a mile or more in thickness, extending south some thousands of miles from the vicinity of Labrador, and covering a large part of the

northeastern portion of the United States. Think how such a mass of ice, sliding over the solid rock, would scratch it, break off chunks, and grind them to bits like a giant crusher. Such an ice-cap still covers all but the fringe of Greenland. It and its deposits there have been studied, and substantiate this conception.

Ice-caps near the pole are easily visualized, but ice-caps near Joliet, which is much nearer to the equator, are incongruous. But consider the large portion of North America that was covered by the sea in which the Niagaran dolomite formed. Outcrops of this formation are found near the north tip of Greenland as well as near Joliet. At Joliet and also in Greenland this formation carries among other forms fossil corals. Corals are now limited to warm, clear, shallow seas. The only explanation is that during the Niagaran epoch it was warmer here and in Greenland than it is now. In short, we know that at different times and in different places greatly different temperatures have prevailed.

Regional study leads to the conclusion that the ice moved out from two or three main centers, although the Labrador ice-sheet is the only one known to have covered the area about Joliet. Regional studies have also shown that four or five ice-sheets covered parts of the United States at different times, but the deposits of the last, or so-called Wisconsin sheet, are the only ones commonly recognized in this area.

Along Kankakee River, however, remnants of an earlier glaciation are well exposed. These were probably deposited by the Illinoian ice-sheet; they are separated from the Wisconsin deposits by an old soil buried under loess (fine, silty material) and lying on lake clays and gravel-sand deposits.

The Wisconsin ice-sheet advanced as far south as Cumberland County in Illinois. Its front remained there long enough so that a notable deposit of material—the Shelbyville moraine—was laid down. The edge of an ice-sheet, although it may temporarily hold a constant position, is far from static. Melting and evaporation cause a notable loss all the time, and it is only by the continued outward movement of the ice that its edge remains more or less

fixed. If melting and evaporation are less important than outward movement, the ice edge advances; if more important, it retreats. But even while the ice edge is retreating, the movement of the ice itself is always outward, and thus materials scraped up within constantly tend to be shifted out to the edge of the ice.

Following the deposition of the Shelbyville and two minor moraines, the ice edge next assumed a constant position over the site of the Bloomington moraine. At the time this moraine was forming at the ice edge, minor deposits were laid down here and there under the ice well back from its edge. One such deposit exists seven miles west of Joliet along a minor tributary of Du Page River. This is protected by later glacial deposits and is fifteen miles southeast of the nearest large body of Bloomington drift. It was recognized by its characteristic pink color.

Later the ice retreated to the position of the Marseilles moraine where its edge again remained constant for probably a few centuries while this moraine was built.

Following the building of the Marseilles moraine, the ice edge suffered great changes, and when it again became temporarily constant its shape in Illinois was fundamentally different, since it lacked the bulge so marked in it at an earlier date. The diminutive Minooka moraine next formed can be traced from Elgin to the head of Illinois River where it has been cut off. Its extension was probably to the southeast under younger moraines.

The retreat to this position first uncovered the general course of Kankakee River, and the present stream presumably had its inception at this time from the waters formed by the melting ice. But the present course of the river was dammed by the massive Marseilles moraine. As a result, a large lake formed. Its surface rose until it reached the level of the lowest gap in the Marseilles moraine. At different times when the flow of water was great several low gaps may have been in use, but finally all the waters were concentrated in the present outlet. The lake lasted a long time—probably until after the ice-sheet had retreated some distance from Illinois—but its level in general dropped (except during two temporary halting stages) as the outlet was cut down, and finally it was completly drained.

Following the Minooka stage, there was pronounced retreat of the ice and the country at least as far as five miles east of Joliet was uncovered. An extensive gravel sheet (the Joliet outwash plain) sweeping out from the ice edge was formed; then the glacier advanced and the Rockdale moraine was deposited. This sequence of events is indicated by the buried gravel sheet seen at many places near Joliet.

During the retreat from the Rockdale moraine the minor Manhattan ridge was formed. Later the extensive Valparaiso morainic system was built, and then the ice-sheet receded in an irregular fashion into the Lake Michigan basin. Figure 2 shows the general sequence in cross-section.

Following the retreat into the Lake Michigan basin, a large lake known as Lake Chicago developed between the edge of the ice-sheet and the Valparaiso moraine, which acted as a dam. The waters thus impounded rose to the level of the lowest gap in the Valparaiso moraine, which was near Lemont. Here they overflowed and followed valleys already established by the outwash waters from the Valparaiso ice-sheet. They wore away the materials of the moraine, and lowered the outlet. These materials, with those formed as outwash from the Valparaiso ice-sheet, were spread out downstream, and now constitute the great gravel deposits near Plainfield and between Joliet and Channahon.

By the time the Lake Chicago outlet was formed, the Kankakee flood had subsided, for the Erie basin waters were diverted into Lake Chicago. Since then the Kankakee has been a little river in a big valley. As the ice retreated farther northward the present St. Lawrence drainage was established and the diminutive Des Plaines River inherited the broad valley of the old outlet of Lake Chicago. Thus two mighty rivers had their rise and decline during minor stages of the last continental glaciation. Recently man has attempted to improve his condition by digging a ditch down the old Lake Chicago outet valley, and endeavoring to bring back the old drainage in a very small way—but there has been opposition to this "reversion to nature".

Fig. No. 1—Index map showing line of cross sections in Figs. 2 and 3 (A-A).

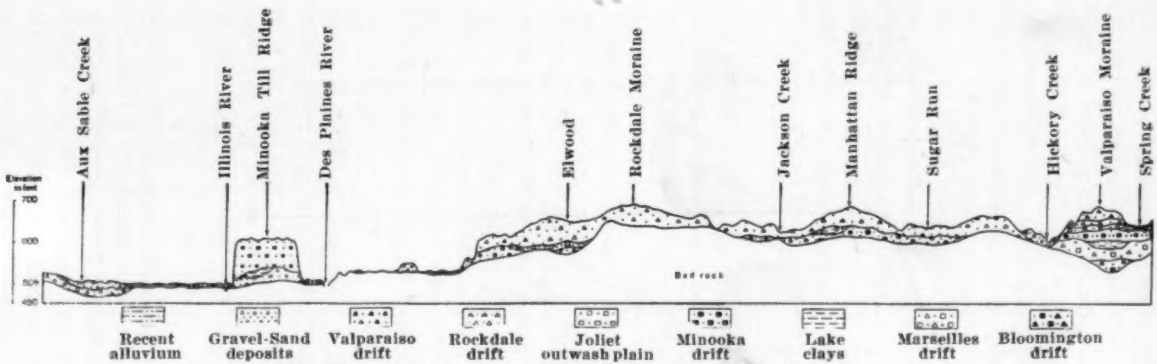

Fig. No. 2—Details of mantle rock deposits of Fig. No. 3.

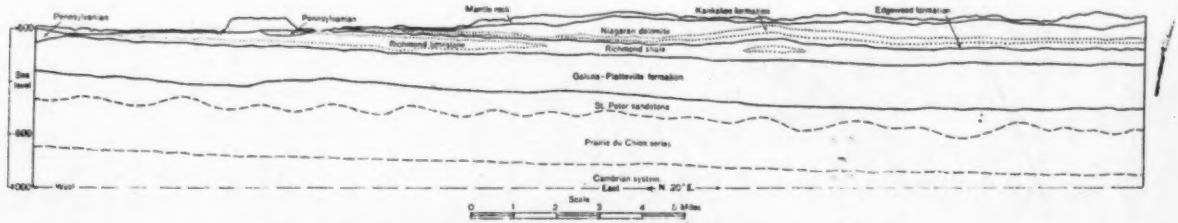

Fig. No. 3—Diagrammatic cross-section along line A-A (Fig. 1) showing strata of the Joliet District.

In summary—the area has had a long history; this paper skims over only a little of it. And the life side has been sadly neglected in favor of the physical side. But one can be sure that each physical change—and geologic history is replete with such changes—has had its effect on whatever forms of life were existing, and these had to meet the new environment imposed on them. Whole tribes have been driven out, suffered changes, and re-invaded the area. And now man is here. Perhaps we are living in an interglacial epoch. Another ice-advance may drive our remote descendants south, just as the last one forced primitive man in Europe to seek regions of warmer climates. But we are far more able to cope with new physical conditions imposed on us than has been any form of life known to have existed in the past. We owe much of our present condition to the striving of life down the long ages. Let us constantly aim to deserve that which we now have by contributing our share to the needs of the future.

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PAPERS IN BIOLOGY AND AGRICULTURE SECTION, JOLIET.

THE GENUS PEPEROMIA IN NORTHEASTERN SOUTH AMERICA.*

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I. Introduction.

In 1775, nineteen years before Ruiz and Pavon established the genus *Peperomia*, Aublet reported fourteen species of *Piper* from Cayenne. Later, eight of these were transferred to the genus *Peperomia*. Richard Schomburgk published a flora of British Guiana in 1848, and included in this were fourteen Peperomias. Fifty-eight years afterward, in 1906, Pulle enumerated fourteen species of this genus as known from Surinam. The Peperomias of the Guianas were also included by Miquel in his monographic study of the Piperaceae and by Casimir de Candolle in the Candollean Prodromus and post-humously in volume one of Candollea. In 1900 Dahlstedt published a comprehensive study of the genus in which most of the species occurring in the Guianas were reported. Other authors dealing with this group of plants are indicated by the references in connection with the synonyms of each species.

There are twenty species included in the present study and these account for all the Peperomias reported for the Guianas in the above-mentioned works. In addition to the twenty, *Peperomia piperea*, reported by Casimer de Candolle in Seemann's Journal of Botany on a Parker specimen at Kew, requires mention. However, the type specimen does not represent a *Peperomia* but consists of foliage apparently of some aroid and an isolated spike of some *Piper*.

Of the twenty known species from the Guianas two are reported as common to the three countries, five from Cayenne and Surinam, three from Cayenne and British Guiana, two from Cayenne, three from Surinam, and five from British Guiana.

The Guianas have low alluvial coast-lands which average about twenty miles in width. These are only a few feet

*The substance of a Thesis in candidacy for the Master's degree at the University of Illinois, in 1926.

above high-water level and back of them is the old marine beach which averages about 100 feet in height. This gradually rises toward the mountain ranges and elevated plateaux where large expanses of open savannas are found. Almost the entire seaward slope is covered with dense primeval forests as would be expected in a country where heat and moisture prevail throughout the year. The mean temperature is about 80 F. and the mean annual rainfall in the coast-lands exceeds 100 inches.

The Peperomias are for the most part endemic to the Guianas due to the fact that these countries are more or less isolated by geographic barriers. They are bounded on the West by the Orinoco River valley, on the south by the Amazon valley, and on the north by the Atlantic Ocean. The Tumuchumac Mountain Range, which lies between the Guianas on the south and the Amazon valley, has an arid region on the Brazilian slope which forms an effective ecological barrier. A few Peperomias are quite wide spread, appearing as weeds in many countries. It is entirely possible that these have crept in along the valleys of the tributaries to the Orinoco and Amazon Rivers.

This study was made from dried herbarium specimens and from drawings and notes of plants in European herbaria made by Dr. William Trelease, to whom the author wishes to acknowledge her great indebtedness not only for the use of his manuscripts but also for the suggestion of the problem and for aid and criticism while the work was being done.

All published references to collections of Peperomias from the Guianas and all specimens which Dr. Trelease or the author have seen are included in the account.

As furnishing the simplest method of determining the species they have been keyed out on the vegetative characters. Following this is a key based on the more fundamentally important fruit characters. The species are arranged under the subgeneric names employed by Dahlstedt.

II. Key Based on Vegetative Characters.

1. Leaves opposite or whorled. 2.
   Leaves alternate. 5.
2. Leaves whorled. 19. P. Schomburgkii.
   Leaves opposite. 3.
3. Stem 4-angled: plant glabrous. 18. P. angulata.

Stem not 4-angled: plant sparsely puberulent. 4.
4. Leaves orbicular. 21. P. circinata.*
Leaves obovate or elliptic-rhomboid. 10. P. blanda.
5. Leaves pinnately nerved. 6.
Leaves palmately nerved. 13.
6. Leaves peltate. 1. P. variegata.
Leaves not peltate. 7.
7. Plants at least slightly pubescent. 8.
Plants glabrous. 9.
8. Leaves ovate-lanceolate, pellucid dotted. 4. P. surinamensis.
Leaves lance-elliptic, not pellucid dotted. 8. P. longemucronata.
9. Leaves more than 10 cm. long. 10.
Leaves 10 cm. or less long. 11.
10. Leaves ovate- or elliptic-oblong: blade decurrent on petiole. 2. P. Parkeriana.
Leaves oblanceolate: blade not decurrent on petiole. 3. P. longifolia.
11. Leaves usually with dendritic exudate or pellucid. 5. P. macrostachya.
Leaves without dendritic exudate or pellucidness. 12.
12. Leaves obovate-oblong or obovate-elliptic: 5-6 cm. wide. 7. P. magnoliaefolia vr. grandifolia.
Leaves obovate-oblong or oblong-spatulate: 2. 5-3. 5 cm. wide. 6. P. obtusifolia var. macropoda.
13. Plants glabrous. 14.
Plants pubescent. 15.
14. Leaves with cordate base. 17. P. pellucida.
Leaves with acute base: blade decurrent on petiole. 11. P. acuminata.
15. Leaves 1.5 cm. or more long. 16.
Leaves less than 1.5 cm. long. 18.
16. Leaves round-ovate. 14. P. roraimana.
Leaves lanceolate or elliptic. 17.
17. Apex of leaves acuminate or acute: leaves 2-6 cm. long. 12. P. melanostigma.
Apex of leaves bluntish: leaves about 2.8 cm. long. 16. P. purpurinervis.
18. Leaves dark-punctulate. 13. P. rotundifolia.
Leaves not dark-punctulate. 19.
19. Leaves elliptic. 15. P. Bartletti.
Leaves reinform or rounded. 9. P. repens.

III. Key Based on Fruit Characters.

1. Berries without a pseudocupule. 2.
Berries with a distinct pseudocupule. 18. (Subgenus *Micropiper*).
2. Stigma at base of an oblique beak. 3.
Stigma terminal on a conic appendage. (Subgenus *Ogmocarpidium*) 17. P. pellucida.
3. Berries cylindric-ovoid: beak mostly elongated. 4. (Subgenus *Rhyncophorum*).
Berries subglobose: obliquely short beaked. 12. (Subgenus *Sphaerocarpidium*)
4. Leaves peltate. 1. P. variegata.
Leaves not peltate. 5.
5. Blade decurrent on the petiole. 6.
Blade not decurrent on the petiole. 7.
6. Spikes opposite the leaves: leaves about 11 cm. long. 2. P. Parkeriana.

*Not known from the Guianas.

Spikes in terminal panicle: leaves about 20 cm. long. 3. P. longifolia.
7. Leaves usually with dendritic exudate or pellucid. 8.
Leaves without dendritic exudate and not pellucid. 9.
8. Leaves pellucid: petiole ciliolate: berries 1 cm. long. 4. P. surinamensis.
Leaves often with dendritic exudate: petiole glabrous: berry 2 cm. long. 5. P. macrostachya.
9. Leaves pubescent. 10.
Leaves glabrous. 11.
10. Leaves small (5-14 mm. long). 9. P. repens.
Leaves moderate (about 7.5 cm. long). 8. P. longemucronata.
11. Leaves 2.5-3.5 cm. wide: berries ellipsoid. 6. P. obtusifolia var. macropoda.
Leaves 5-6 cm. wide: berries ovate-globose. 7. P. magnoliaefolia var. grandifolia.
12. Leaves opposite. 10. P. blanda.
Leaves alternate. 13.
13. Leaves at least sparsely black-punctulate or black-granular. 14.
Leaves not black-punctulate. 17.
14. Blade decurrent on petiole. 11. P. acuminata.
Blade not decurrent on petiole. 15.
15. Leaves round, round-ovate, or obovate-elliptic. 16.
Leaves lanceolate or elliptic. 12. P. melanostigma.
16. Leaves very small (5-10 mm. long). 13. P. rotundifolia.
Leaves a little larger (15-25 mm. long). 14. P. roraimana.
17. Leaves less than 15 mm. long. 15. P. Bartletti.*
Leaves more than 20 mm. long. 16. P. purpurinervis.*
18. Spikes axillary. 18. P. angulata.
Spikes terminal. 19.
19. Leaves opposite. 21. P. circinata.†
Leaves whorled. 19. P. Schomburgkii.

IV. Classified Enumeration, With Descriptions.

SUBGENUS RHYNCOPHORUM

1. Peperomia variegata. R. & P.

Peperomia variegata R. & P. Fl. Peruv. 1:33, 1798.—C. DC. in Cand. 1:375, 1923.

Peperomia maculosa Auct. as to Cayenne.

A short, glabrous herb; stem stout (5-7 mm.), smoky- or violet-spotted; leaves alternate, broadly ovate-elliptic, short acuminate, peltate scarcely 2 cm. above the round or sub-cordate base, very large (8.5-10×10-15 cm.), multiple nerved; petiole very long (8-10 cm.); spikes terminal, one or two on a common peduncle (about 2 cm. long), thick and very long (.5×15-18 cm.); individual peduncles long (1.5-2 cm.); bracts round-peltate; ovary ovoid, obliquely long-beaked; stigma nearly in center of beak.

Type locality: Pillao at Chacabuossi, Peru.

Collections: *Cayenne* (fide Aublet, Hist. p. 22).

2. Peperomia Parkeriana Miq.

Peperomia Parkeriana Miq. in Hook. Lond. Journ. Bot.

*Placed in Sphaerocarpidium although the stigma is described as apical.
†Not known from the Guianas.

4:427, 1845.—C. DC. in DC. Prod. 16′:425, 1869.—C. DC. in Cand. 1:370, 1923.

A terete, glabrous herb; leaves alternate, ovate- or elliptic-oblong, acuminate, decurrent on petiole, very large (5×11 cm.), pinnately nerved from below the middle, the nerves 3-4×2; petiole moderate (1.5 cm.); spikes filiform, opposite the leaves, closely flowered; peduncle moderate (1.5 cm.); ovary beaked; stigma in middle of beak.

Type locality: Lower Surinam River, near Geyersvlyt, Surinam.

Collections: *Surinam* (Kegel 1005 at Göttingen) Miquel. *British Guiana* (Parker at Kew) C. DC.

3. Peperomia longifolia C. DC.

Peperomia longifolia C. DC. in DC. Prod. 16′:405, 1869.—C. DC. in Cand. 1:289, 1923.

A shortly caulescent, erect, glabrous herb; leaves alternate, oblanceolate, acuminate, mucronulate, decurrent on petiole, very large (4.5×20 cm.), pinnately nerved; petiole long (4 cm.); spikes short (10-15 mm.), in terminal panicle, closely flowered; peduncle short (4 mm.); bracts round-peltate, glandular; ovary compressed, ovoid; berries cylindric-ovoid, obliquely short beaked.

Type locality: *Cayenne* (apparently near the city Cayenne)

Collections: *Cayenne* (Richard at Paris) Trelease; (Le Prieur at Paris) Trelease.

Also reported from Costa Rica presumably on a different species.

4. Peperomia Surinamensis C. DC.

Peperomia surinamensis C. DC. in DC. Prod. 16′:408, 1869.—C. DC. in Cand. 1:353, 1923.

A suffruticose, scandent plant, rooting at the nodes; stem ciliolate near the end; leaves alternate, ovate-lanceolate, acuminate, ciliolate near the end, membranaceous, pellucid, large (2-5×6-9 cm.), (Kappler specimen 2-2.5×4.5-6 cm.), pinnately 7-nerved from below the middle; petiole moderate (1.5 cm.), ciliolate above; spikes longer than the leaf, (Kappler specimen shorter than leaf, 3.5 cm.), solitary at the end of stem, closely flowered; peduncle long (3 cm.); bracts round-peltate; ovary half-immersed; berries cylindric-ovoid, 1 mm. long, black, obliquely subacute.

Type locality: Paramaribo, Surinam.

Collections: *Surinam* (Kappler 1577 in Hb. DC. at Geneva) Trelease. *Cayenne* (Sagot 538 in Hb. Lenormand at Caen) C. DC. *British Guiana* (de la Cruz 1304 at N.Y. B. G.) Bailey; (de la Cruz 1365 at N.Y.B.G.) Bailey; (de la Cruz 1520 at N.Y.B.G.) Bailey.

5. Peperomia macrostachya (Vahl) Dietr.

Peperomia macrostachya (Vahl) Dietr. Sp. 1:149, 1831.—C. DC. in DC. Prod. 16′:439, 1869.—Dahlst. Stud. 88, 1900.

Piper macrostachyon Vahl Enum. 1:341, 1804.

Piper myosuroides Rudge Pl. Guian. Rar. pl. 5, London, 1805.

Peperomia myosuroides (Rudge) Dietr. Sp. 1:157, 1831.—C. DC. in DC. Prod. 16′:407, 1869.—C. DC. in Cand. 1:365, 1923.—Miq. Syst. Pip. 184, 1843.

Peperomia rupestris HBK. in Nov. Gen. 1:62, 1815 as to collections of Seeman (608) and Kegel (1037) from Surinam.

Peperomia myriocarpa Auct. as to Cayenne.

Peperomia distachya as to collections of Poiteau, Focke, and Miquel from the Guianas.

Peperomia nematostachya Auct. as to the Guianas.

A trailing, essentially glabrous herb; leaves alternate, subovate-elliptic, acuminate, base rounded, moderate (1.5-3.5×6-9 cm.), lepidote above with dendritic exudate*, pinnately nerved; petiole short to moderate (3-20 mm.); spikes filliform (10-30 cm.), subpanicled on bracted branches opposite the leaves or apical, closely flowered; peduncle short to long (5-20 mm.); bracts round-subquadrangular, peltate, fringed; berries cylindric, 2 mm. long, scutulate; stigma subapical.

Type locality: Cayenne.

Collections: *Cayenne* (Rich. at Paris) Trelease; (Sagot 538 at Kew) C. DC.; (Martin in Hb. Rudge in Brit. Mus. at London) C. DC.; (Poiteau in Hb. Delessert at Geneva) Trelease; (Sagot at Stockholm) Dahlst. *Surinam* (Humb. in Hb. Willdenow at Berlin) Dahlst; (Near Kangaruma, Potaro R., Bartlett 8741 at N.Y.B.G.) Bailey; (Seemann 608 at Kew) C. DC. *British Guiana* (de la Cruz 3615 at N.Y.B.G.) Trelease; (Macbride 6001 in Hb. U. of Ill. at Urbana) Bailey; (Kabakaburi, Pomeroon District, de la Cruz 3240 at N.Y.B.G.) Bailey; (Dense upland forest, Rockstone, Gleason 564 at N.Y.B.G.) Bailey; (dry sandhills, east of Rockstone, Gleason 810 at N. Y. B. G.) Bailey.

Also reported from Brazil.

*The original description of Piper myosuroides by Rudge included mention of stellate scurfiness which is frequently seen but consists of dendritically divided exudate from the leaf rather than pubescence.

6. PEPEROMIA OBTUSIFOLIA (L.) A. DIETR. VAR. MACROPODA (MIQ.) DAHLST.

Peperomia obtusifolia (L.) A. Dietr. var. macropoda (Miq.) Dahlst. Stud. 65, 1900.

Peperomia macropoda Miq. in Linn. 20:128, 1844.—C. DC. in DC. Prod. 16′:428, 1869.

A creeping, glabrous herb; stem thick, rooting at the nodes, apex and branches ascending; leaves alternate, obovate-oblong, or oblong-spatulate, base attenuate or cuneate, large (2.5-3.5×6-9 cm.), pinnately nerved; petiole usually long (1-7 cm.); spikes long (11-14 cm.), terminal or axillary, closely flowered; peduncle long (7 cm.); bracts round-peltate; berries ellipsoid with beak (about 2 mm. long); stigma anterior on the beak.

Type locality: Brazil.

Collections: *Surinam* (Kegel 1252a and b at Göttingen) Dahlst. *Cayenne* (Richard at Paris) Trelease; (Le Prieur at Paris) Trelease.

Also reported from St. Vincent, St. Domingo, Porto Rico, Mexico, and Nicaragua presumably on different species.

7. PEPEROMIA MAGNOLIAEFOLIA (JACQ.) A. DIETR. VAR. GRANDIFOLIA MIQ.

Peperomia obtusifolia Miq. Syst. Pip. 194, 1843 (in part).

Peperomia obtusifolia Dietr. var. *grandifolia* Miq. Syst. Pip. 196, 1843.

Peperomia magnoliaefolia (Jacq.) A. Dietr. var. *Sintenisiana* Dahlst. Stud. 59, 1900, as to Surinam.

An erect or ascending, branched, glabrous herb, often rooting at the nodes; leaves alternate, obovate-oblong, or obovate-elliptic, apex rounded or obtuse, fleshy with thin margins, large (5-6×9-10 cm.), pinnately nerved, middle nerve thick below; petiole long (2-4 cm.); spikes very long (19-20 cm.), terminal or terminating lateral branches, closely flowered; peduncle very long (5-10 cm.); bracts round-peltate; berries ovate-globose.

Type locality: Caracas, Venezuela.

Collections: *Surinam* (Hostmann 260 in Hb. Delessert at Paris) Trelease; (Hostmann 260 at Berlin) C. DC.; (Kegel 806 at Göttingen) Dahlst.; (Kegel 619 at Göttingen) Dahlst.; (Wullschaegel 480 at Munich and in Hb. Grisebach at Göttingen) Dahlst.; (R. F. Hohenacker 401a at Stockholm) Dahlst.

Also reported from Brazil, Porto Rico, and Grenada.

8. Peperomia longemucronata C. DC.

Peperomia longemucronata C. DC. in Notizbl. Berlin 7:497, 1917.—C. DC. in Cand. 1:364, 1923.

A slightly pubescent herb; leaves alternate, lance-elliptic, acute at both ends, moderate (4×7.5 cm.), pinnately nerved, pubescent on nerves on upper face, paler beneath; petiole moderate (2 cm.); spikes long (10 cm.), paired, terminal, loosely flowered; peduncle long (1.5 cm.); peduncle-bearing branches 5.5 cm. long; bracts large (¾ mm.), round-peltate; berries thick-ellipsoid; scutulem acuminate; stigma median, sessile.

Type locality: Roraima, Britsh Guiana.

Collections: *British Guiana* (Ule 8594 in Hb. DC. at Geneva) Trelease.

9. Peperomia repens HBK.

Peperomia repens HBK. in Nov. Gen. 1:65, 1815.—Dahlst. Stud. 79, 1900 (in part).

Peperomia scandens Auct. as to the Guianas.

A small creeping, somewhat crisply pubescent herb, rooting from the nodes; leaves alternate, reniform or rounded, apex sometimes subacute, small (.5-1.5×.7-1.4 cm.), palmately 3- or obscurely 5-nerved; petiole moderate (3-10 mm.); spikes short (10-15 mm.), terminal; peduncle long (2 cm.), commonly bracted in the middle; berries cylindric, beaked; stigma anterior at base of beak.

Type locality: near Cumanacoa, Venezuela.

Collections: *Surinam* (Focke in his personal herbarium) Miq.; (Hostmann and Kappler 117 at Munich) Dahlst.; (Hostmann 629 at Stockholm) Dahlst.; (Wullschaegel in Hb. Grisebach at Göttingen) Dahlst. *Cayenne* (Le Prieur in Hb. Delessert at Geneva) C. DC.; (Martin in Hb. British Museum at London) C. DC.

Also reported from Brazil.

SUBGENUS SPHAEROCARPIDIUM

10. Peperomia blanda

Peperomia blanda HBK. in Nov. Gen. 1:67, 1815.—Miq. Syst. Pip. 115, 1847.—C. DC. in DC. Prod. 16′:458, 1869.—Dahlst. Stud. 131, 1900.

Peperomia Langsdorffii Miq. Syst. Pip. 116, 1843.—Miq. in Linn. 20:124, 1847.—C. DC. in DC. Prod. 16′:443, 1869.

Micropiper Langsdorffii Miq. in Comm. Phyt. 2:52, 1840.

Peperomia polystachya Auct. as to the Guianas.

A branched, erect, slightly suffruticose, pubescent herb, scarcely a foot high; leaves opposite or whorled, upper ones alternate, obovate- or elliptic-rhomboid, apex acute, base cuneate, pubescent on both

faces, moderate (1.5-3×2.5-8 cm.), upper ones smaller, palmately 3-nerved; petiole moderate (.5-1.5 cm.); spikes long (8-12 cm. long), terminal in twos, threes, or more, or in axils of terminal leaves; peduncle moderate (1-1.5 cm.); bracts oblong, truncate, peltate; ovary emersed-impressed; berries obliquely ovoid, short-beaked.

Type locality: Venezuela.

Collections: Reported by Schomburgk from *British Guiana* as *Peperomia polystachya* A. Dietr.

Also reported from Colombia, Educador, Brazil, and Bolivia. Also from the West Indies presumably on a different species.

11. Peperomia acuminata (L.) Dahlst.

Peperomia acuminata (L.) Dahlst. Stud. 123, 1900.

Piper acuminatum L. Sp. Plant. ed. 2:42, 1762.

Peperomia acuminata (L.) Dietr. Sp. 1:148, 1831 (in part).—Miq. Syst. Pip. 95, 1843 (in part).

Peperomia nemorosa (Vahl) C. DC. in DC. Prod. 16′:415, 1869 (in part).

Peperomia obliqua Auct. as to British Guiana.

An erect, glabrous herb; leaves alternate, lower ones often obovate-elliptic, upper ovate-elliptic, apex acuminate, base acute, decurrent on petiole, moderate (3.5×7 cm.), membranaceous, pellucid-punctate, sparsely black-punctulate below, palmately 3-5-nerved; petiole moderate (12 mm.); spikes almost twice surpassing the leaves, axillary and terminal; bracts round-peltate; ovary half-immersed; berries subrotund-acute, apex with small beak.

Type locality: Based on Plumier's plate 71 from West Indies.

Collections: *Cayenne* (fide Aublet, Hist. p. 21) *British Guiana* (fide Schomburgk, Fauna und Flora p. 18).

Also reported from Jamaica, Porto Rico, St. Bartholomew, St. John, Antigua, Dominica, Martinique, and St. Vincent.

12. Peperomia melanostigma Miq.

Peperomia melanostigma Miq. Syst. Pip. 90, 1843.—C. DC. in DC. Prod. 16′:408, 1869 and varieties.

Peperomia velloziana polystica Miq. in Linn. 18:226, 1844.—C. DC. in DC. Prod. 16′:408, 1869.

Peperomia glabella melanostigma C. DC. in Cand. 1:326, 1923.

A suffruticose, branched, puberulent herb, rooting at the nodes; leaves alternate, petioled, lanceolate or elliptic, acuminate or acute, black punctulate, moderate (1-2×2-6 cm.), obscurely palmately 3-5-nerved; petiole moderate (.5-1 cm.); spikes 7-20 cm. long, axillary or

terminal, loosely flowered; peduncle long (1.5-2 cm.); berries ovate, beaked.

Type locality: near Paramaribo, Surinam.

Collections: *Surinam* (Hostmann 437 at Berlin) Miq.; (Focke in his own personal herbarium) Miq.; (Hostmann 437 at Paris) Trelease; (Hostmann-Hohenacken 799a at Paris) Trelease; (Kegel 437 at Paris) Trelease. *Cayenne* (Melinon 171 at Paris) Trelease; (Le Prieur at Paris) Trelease.

13. PEPEROMIA ROTUNDIFOLIA (L.) HBK.

Peperomia rotundifolia (L.) HBK. in Nov. Gen. 1:65, 1815.

Peperomia rotundifolia (L.) Dahlst. Stud. 99, 1900 and varieties.

Piper rotundifolium L. Sp. Plant. 30, 1753.

Piper nummularifolium Sw. Prod. 16, 1788.

Peperomia nummularifolia HBK. in Pl. Aeq. 1:66, 1808.—HBK in Nov. Gen. 1:66, 1815.—C. DC. in DC. Prod. 16′:420, 1869.

Acrocarpidium nummularifolium Miq. Syst. Pip. 52, 1843.

Peperomia metapalcoensis Auct. as to the Guianas.

A small, delicate, slightly pubescent herb, rooting at the nodes; leaves alternate, round to obovate-elliptic, small (5-6×5-10 mm.), obscurely palmately 3-nerved, more or less hairy on both sides or glabrous, somewhat dark-punctulate; petiole short (1-3 mm.); spikes short (10-20 mm.), terminal, subverticillately and remotely flowered; peduncle short (2-5 mm.); bracts round-peltate; berries round-ellipsoid; stigma slightly anterior.

Type locality: Martinique.

Collections: *Surinam* (Weigalt at Berlin and Munich) Dahlst.; (Hb. Krug and Urban at Berlin) Dahlst.; (Weigelt in Hb. DC. at Geneva) Trelease; (Hostmann 117 at Berlin and Stockholm) Dahlst.; (Wullschlaegel 485 in Hb. Grisebach at Göttingen and Hb. Krug and Urban at Berlin) Dahlst.; (Kappler 672 at Stockholm) Dahlst. *Cayenne* (fide Aublet, Hist. p. 21.); (Sagot 903 at Berlin) Dahlst.; (Le Prieur in Hb. Franqueville at Paris) C. DC.

Also reported on various scarcely separable forms from Paraguay, Brazil, Venezuela, Ecuador, Colombia, Costa Rica, Guatemala, Mexico, Cuba, Jamaica, St. Domingo, Porto Rico, St. Bartholomew, Antigua, Guadeloupe, Dominica, Martinique, St. Lucia, Grenada, and Trinidad.

14. PEPEROMIA RORAIMANA C. DC.

Peperomia roraimana C. DC. in Notizbl. Berlin 7:493, 1917.*—C. DC. in Cand. 1:328, 1923.

A branched, erect, crisply pubescent herb; leaves alternate, round-ovate, obtuse or acutish, round-based, sparsely pubescent on both faces, black-granular, small (1.5-2×1.5-2.5 cm.), palmately 3-5-nerved; petiole short (.5 cm.), crisply pubescent; young spikes short (1.5 cm.), terminal and axillary; young peduncle short (3 mm.) glabrate; berries sessile, stigma oblique.

Type locality: Roraima, British Guiana.

Collections: *British Guiana* (Ule 8593 at Berlin) C. DC.; (Ule 8593 in Hb. DC. at Geneva) Trelease.

15. PEPEROMIA BARTLETTI *C. DC.*

Peperomia Bartletti C. DC. in Notizbl. Berlin 7:470, 1917*.—C. DC. in Cand. 1:334, 1923.

A small, delicate, arboricolous, sparsely hairy herb; leaves alternate, elliptic, rounded above, acute based, small (7×13 mm.), palmately 3-nerved, pubescent above, ciliate; petiole short (2 mm.); spikes (2 cm.), solitary, terminal, filiform; peduncle moderate (5 mm.); stigma not lobed, sessile, apical.

Type locality: Conanaruk river, British Guiana.

Collections: Conanaruk river, *British Guiana* (H. H. Bartlett 8233, from Berlin, in Hb. DC. at Geneva) Trelease.

16. PEPEROMIA PURPURINERVIA C. DC.

Peperomia purpurinervia C. DC. in Notizbl. Berlin 7:496, 1917*.—C. DC. in Cand. 1:345, 1923.

An epiphytic herb with stem minutely puberulous upwards; leaves alternate, elliptic, bluntish, acute-based, minutely ciliate upwards, small (1.7×2.8 cm.), palmately 3-nerved; petiole short (5 mm.), purplish; spikes short (5.5 cm.), terminal, closely flowered; peduncle moderate (1.5 cm.); stigma apical, sessile.

Type locality: Roraima, British Guiana.

Collections: *British Guiana* (Ule 8592 at Berlin) C. DC.

SUBGENUS OGMOCARPIDIUM.

17. PEPEROMIA PELLUCIDA (L.) HBK.

Peperomia pellucida HBK in Nov. Gen. 1:64, 1815.—Miq. Syst. Pip. 79, 1843.—C. DC. in DC. Prod. 16′:402, 1869.—Dahlst. Stud. 16, 1900.

Piper pellucidum L. Sp. Plant. 21; 1753.

An erect, glabrous herb; leaves alternate, deltoid-cordate to ovate-cordate, apex acuminate, pellucid-punctate, leaves small (1.5-

*The volume number 7 of Notizbl. as given in Clavis is correct although the number of Notizbl. containing the article and separates of the article made from it were erroneously marked as of distributed volume 6.

2.5×1.5-2.5 cm.), palmately nerved; petiole moderate (1.5 cm.); spikes moderate (2-5 cm.), opposite the leaves (Miquel gives them as axillary or terminal), loosely flowered; bracts round-peltate, shortly pedicelled; ovary oblong-cylindrical; berries ovoid; stigma on a conic appendage.

Type locality: Based on Plumier's plate 72 from Martinique.

Collections: *Surinam* (Hostmann 65 in Hb. Boissier at Geneva) C. DC.; (Hostmann and Kappler 65 at Stockholm and Hb. Grisebach) Dahlst.; (Kegel 476) fide Miq. in Linn. 22:76, 1849. *Cayenne* (Sagot in Hb. Franqueville at Paris) C. DC.; Sagot 523 at Stockholm) Dahlst. *British Guiana* (Schomburgk 939 at Kew) C. DC.; (Schomburgk 939 at Berlin) Dahlst.

Also reported from Jamaica, Hispaniola, St. Croix, St. Thomas, Guadeloupe, St. Vincent, Barbados, Grenada, Tobago, Colombia to Peru, Venezuela to Brazil, and Africa.

SUBGENUS MICROPIPER.

18. PEPEROMIA ANGULATA (R. & S.) HBK.

Peperomia angulata (R. & S.) HBK. in Nov. Gen. 1:66, 1815.—Miq. Syst. Pip. 180, 1843.—C. DC. in DC. Prod. 16′:446, 1869.—C. DC. in Cand. 1:317, 1923.—Dahlst. Stud. 156, 1900 and variety.

Piper angulatum R. & S. Mant. 1:332, 1822.

Peperomia trifolia Auct. as to Cayenne.

A repent, glabrous herb; stem 4-angled; leaves opposite, obovate, obtuse, base cuneate, small (15×25 mm.), palmately 3-nerved, the nerves prominent beneath; petiole short (3 mm.); spikes short (about 30 mm.) axillary, closely flowered, filiform; peduncle very long (30 mm.), scaly; bracts round-peltate, glandular-punctate; ovary immersed, oblong; stigma apical.

Type locality: Cumana, Venezuela.

Collections: *Surinam* (Hostmann 784 in Hb. Boissier at Geneva) Trelease; (Wullschlaegel in Hb. Grisebach at Göttingen) Dahlst. *Cayenne* (fide Aublet, Hist. p. 22.)

Also reported from Brazil.

19. PEPEROMIA SCHOMBURGKII C. DC.

Peperomia Schomburgkii C. DC. in DC. Prod. 16′:395, 1869.—Dahlst. Stud. 182, 1900.—C. DC. in Cand. 1:294, 1923.

Peperomia quadrifolia Aublet, Hist. 1:21, 1775.

A branched, creeping, nearly glabrous herb; leaves in whorls of four, sub-orbicular, ciliolate, emarginate, drying thick and dull, small

(10×12 mm.), obscurely 3-nerved; petiole short (6 mm.), slightly velvety; spikes much surpassing the leaves, terminal, closely flowered; peduncle moderate (15 mm.); bracts round-peltate, short-stalked; ovary ovoid, short-styled.

Type locality: British Guiana.

Collections: *British Guiana* (Schomburgk 406 at Berlin) C. DC.; (Schomburgk in Hb. D. C. at Geneva) Trelease. *Cayenne* (fide Aublet, Hist. p. 21.)

EXCLUDED FROM THE GUIANA FLORA.

20. PEPEROMIA PIPEREA C. DC.

Peperomia piperea C. DC. in Seem. Journ. 4:143, 1866.

Spike of a Piper and leaf of an aroid.

21. PEPEROMIA CIRCINATA LINK.

Peperomia circinata Link in Spreng., Schrader and Link, Jahrb. 1. 3:64, 1820.—C. DC. in DC. Prod. 16:444, 1869.

This species is reported by C. D.C. from Surinam on a Pohl specimen (number 1217 at Vienna). However it was collected at Parnahyba, Brazil (the label on the specimen which reads Paranahyba was probably misread as Paramaribo).

V. Bibliography.

Aublet, Fusée. Histoire des Plantes de la Guiane Francoise, v. 1. 1775.

Candolle, Casimir de. Piperaceae. Prodromus Systematis Naturalis Regni Vegetabilis, v. 16. Part 1. 1869.

——— ——— Piperaceae Novae. The Journal of Botany, British and Foreign, edited by Berthold Seemann, v. 4. 1866.

——— ——— Piperacearum Clavis Analytica. Candollea, Organe du Conservatoire et du Jardin Botaniques de Genève, v. 1. 1923.

——— ——— ———. Notizbl. Berlin, v. 7. 1917.

Dahlstedt, Hugo. Studien über Süd-und Central-Amerikanische Peperomien. 1900.

Dietrich, A. Linnaeus, Carl, Species Plantarum, ed. 6. 1831-38.

Grisebach, A. Flora of the British West Indian Islands. 1864.

Herbertson, F. D. & A. J. Central and South America with the West Indies. 1902.

Humboldt, F. A. von. Nova Genera et Species Plantarum, v. 1-7. 1815-25.

Humboldt et Bonpland. Plantae Aequinoctiales, v. 1-2. 1808-09.

Keane, A. H. Standford's Compendium of Geography and Travel. Central and South America, v. 2. 1911.

Link, H. F. Der Botanische Garten bei Berlin und die Willdenow'sche Kräutersammlung. Sprengel, Jahrbücher, v. 1. 1820.

Hooker, W. J. Exotic Flora, containing figures and descriptions of new, rare, or otherwise interesting plants, etc. 1823-27.

Linnaeus, Carl. Species Plantarum. ed. 1. 1753, ed. 2. 1762-63.

Miquel, F. A. G. Commentarii phytografici, quibus varia rei herbariae capitula illustrantur. Fasc. 2. Obs. de Piperaceis et Melastomaceis. 1840.

——— ——— Animadversiones in Piperaceas Herbarii Hookeriani. Hooker, London Journal of Botany, v. 4. 1845.

——— ——— Observationes de quibusdam Piperaceis herbarii Schlechtendaliani. Linnaea, v. 18. 1844.

——— ——— Systema Piperacearum. 1843-44.

Plumier, Charles. Description des plantes de l'Amérique avec leur figures. 1693.

Pulle, A. An Enumeration of the Vascular Plants Known from Surinam. 1906.

Ruiz, H. et Pavon, J. Flora Peruviana et Chilensis sive Descriptiones et Icones Plantarum Peruvianarum et Chilensium. 1798.

Roemer et Schultes. Linnaeus' Systema Vegetabilium. 1817, 1822-27.

Rudge, E. Plantarum Guianae rariorum Icones et Descriptiones hactenus ineditae, v. 1. 1805.

Schlechtendal de et Chamisso de. Plantarum Mexicanarum. Linnaea, v. 6:353. 1831.

Schomburgk, Richard. Fauna und Flora von Britisch-Guiana. 1848.

Swartz, Olaf. Nova Genera et Species seu Prodromus descriptionum vegetabilium . . . quae sub itinere in Indiam occidentalem annis 1783-87 digessit. 1788.

——— ——— Observationes Botanicae quibus Plantae Indiae Occidentalis aliaeque Systematis Vegetabilium Ed. XIV Illustrantur Earumque Characteres Passim Emendantur. 1791.

Vahl, M. Enumeratio plantarum etc. 1804-06.

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THE AMERICAN BITHYNIA NOT WHOLLY AN INTRODUCED SPECIES.*

FRANK COLLINS BAKER, CURATOR, MUSEUM OF NATURAL HISTORY, UNIVERSITY OF ILLINOIS.

One of the most abundant species of gastropod mollusks in the United States is the little snail known as *Bithynia tentaculata* first described by the great Linnaeus. Its late appearance in American molluscan literature (1880) and its later appearance in different parts of the Great Lakes area has led to the conclusion that it was introduced from Europe with some sort of cargo. Walker (1918, p. 132) remarks that "This well known European species has been introduced from Europe by commerce and has spread from the Hudson west to Lake Michigan". In a letter to the writer Dr. Walker says "There is no doubt but that this common European species was introduced into America from Europe in the ballast of the timber ships that used to carry long, squared timber from Holland, Saginaw and other Lake Michigan ports, directly to Europe. The species was detected at these points as early as 1891".

The present wide-spread distribution of *Bithynia tentaculata*, now found in all the Great Lakes excepting Lake Superior, in such lakes as Oneida and Cayuga, in New York, Winnebago in Wisconsin, and Black Lake and other inland points in Michigan, in addition to other places in New York State, Erie Canal and Hudson River, taken in connection with its great abundance wherever found, raises the question as to whether it is not another species inhabiting both Europe and America., as *Stagnicola palustris* and *Margaritana margaritifera*. Until recently, its numbers and wide distribution (it seems doubtful that it could spread so far in 48 years, 1879 to 1927) have been the only factors that could be urged for the acceptance of a two continent distribution theory.

Two years ago Dr. Alvin R. Cahn, of the Department of Zoology, University of Illinois, collected a number of

*Contribution from the Museum of Natural History, University of Illinois, No. 46.

Pleistocene fossils from Chicago deposits which included a number of *Bithynia tentaculata*. This material with the associated species, is tabulated below:

I. Southwest corner Michigan Boulevard and Walton Place, nine feet below level of Lake Michigan.

Lampsilis siliquoidea rosacea
Elliptio dilatata
Sphaerium simile
Sphaerium solidulum
Sphaerium flavum
Pisidium virginicum
Pisidium compressum pellucidum
Pleurocera acuta
Goniobasis livescens
Campeloma rufum
Amnicola limosa porata
Valvata bicarinata perdepressa
Bithynia tentaculata

II. Southwest corner Tower Court and Pearson Street, about 15 feet below street level.

Sphaerium solidulum
Sphaerium flavum
Goniobasis livescens
Pleurocera acuta
Bithynia tentaculata

III. Pearson Street, west of Michigan Avenue, about half a mile west of the lake, 25 feet below street level.

Fusconaia undata
Sphaerium solidulum
Sphaerium flavum
Goniobasis livescens
Pleurocera acuta
Planorbis trivolvis, var.
Amnicola limosa porata
Bithynia tentaculata

In the above lists, *Elliptio dilatata* and *Fusconaia undata* are not found in Lake Michigan at the present time, and the latter species is only known as a fossil in the Chicago area, *Fusconaia flava* being the species found in the streams in the vicinity.

The location of the fossil deposits is about a fourth of a mile west of Lake Michigan and half a mile north of the Chicago River, not far from the Chicago Avenue water works. The surface at this point is 10 feet above Lake Michigan level, so that the depths at which fossils were found are from five to 15 feet below lake level, in undisturbed strata. The localities are also about 2000 feet south of the south end of the old Graceland bar and the geological time of the formation was probably the Toleston stage of Glacial Lake Chicago (see Baker, 1920, p. 79, pl. 37, 38).

That this species of *Bithynia* was not found in any of the Wilmette Bay deposits studied in 1910-1912 is perhaps not strange since the portion of the old bay studied did not extend south of Bowmanville, which is about five miles north of the location under discussion.

The present habitat of *Bithynia tentaculata*, in America, is in fairly open water in more or less exposed situations where there is good wave motion (see Baker, 1916, 1924 for habitats in lakes Oneida and Winnebago). It is preëminently a mollusk of vegetation and is seldom found away from it. It is a vegetable eater, being particularly fond of filamentous algae, among which it is usually found in abundance. It is also found on the stems of *Scirpus* and *Elodea*, plants that were common in old Wilmette Bay during Pleistocene times. The lower part of Wilmette Bay was not unlike Winnebago Lake in some respects, being 10 miles long and two miles wide, and rather shallow.

The present American distribution of *Bithynia tentaculata* is as follows, as far as available records have determined.

Wisconsin: Winnebago and Butte des Morts lakes, Calumet and Winnebago counties; Sturgeon Bay, Door Co.; Kenosha Co., Lake Michigan (Baker); Green Bay (Pearse).

Michigan: Black Lake, near Holland, Ottawa Co.; Bay City; Winona Beach, Bay Co.; Muskegon Lake, Muskegon Co.; Lake Michigan, New Buffalo, Berrien Co.; La Plaisance, Monroe Co.; Manistee River, Manistee Co.; Detroit River, Gibraltar, Wayne Co.; Lake Huron, Harbor Beach and Sandusky, Huron Co. (Walker).

Pennsylvania: Erie Harbor, Erie Co. (Walker).

Ohio: Ohio Canal, Stark Co. (Sterki); Ashtabula Harbor, Ashtabula Co. (Streator); mud flats near Toledo, near Maumee Bay, Lucas Co. (Goodrich).

Illinois: Shore of Lake Michigan (Baker).

Indiana: Shore of Lake Michigan (Baker, Daniels).

New York: Oswego, Lake Ontario, Oswego Co.; Erie Canal, Syracuse, Onondaga Co. (Beauchamp); Erie Canal, Rochester, Ontario Co. (Walton); Genessee River, near Rochester and Lake Ontario, Ontario Co.; Thousand Islands, St. Lawrence River; Oneida Lake (Baker); Seneca

River at Waterloo and Cayuga Lake (Maury); Lake Champlain and Niagara Falls (Walker).

Canada: Cornwall and Toronto Bay, Ontario; Duck Island, Ottawa River; Bay of Quinte, near Belleville, Toronto (Latchford).

The fossil *Bithynia* are like the form now living in Lake Michigan. This would suggest that it may be another species of a circumboreal nature, like *Aplexa hypnorum*. It might have been a migrant by way of the northeast land connection and could have reached our shores at the same time as the land snail *Helix nemoralis* which was for a long time thought to be an introduced species until it was finally found in Pleistocene deposits. There seems no question concerning the authentic character of the material from the Chicago deposits as being of Pleistocene age, and representing life that lived at the entrance to Wilmette Bay during the later stages of Glacial Lake Chicago.

A critical examination of specimens from Europe and America seems to indicate that they are not exactly alike, the lake form being heavier, the whorls more rotund, the spire usually shorter and the sutures less deeply impressed than in ditch forms from England. The columellar callus is also usually thicker, forming a rather heavy deposit in the lake shells. These differences reflect a response to a lake environment, the European form living in ditches, small rivers and relatively quiet bodies of water. The American localities, on the other hand, are subject to more or less violent wave action. There also appear to be some differences between the published figures of the radulae of the American and the European form, but whether this is due to differences in drawing the teeth or are real distinctions in the radulae is not at present determinable. It is possible that the American form should be separated as a distinct variety.

It should be noted, however, that it is doubtless true that European specimens of *Bithynia tentaculata* were introduced into American Localities as described by Walker and others. These may have interbred with the native form and produced the heavy lake species now found in the lake. There is also the possibility that *Bithynia* became extinct in Wilmette Bay and that the lake was populated by the

introduced form. There is more variation among the recent than among the fossil forms, some of the former approaching the long-spired forms so characteristic of the European Bythinia. More fossil examples are needed for comparison and the form should be found in additional strata near Chicago and elsewhere.

Published References to American Bithynia.

Anonymous.

1891. Western Range of Bythinia tentaculata (Black Lake, Ottawa Co., Mich., by Dr. De Camp). Nautilus, V. p. 71.

Baker, Frank Collins.

1898. The Molluscan Fauna of Western New York. Trans. Acad. Sci. St. Louis, VIII., p. 92.

1902. Mollusca of the Chicago Area, part II. Bull. Nat. Hist. Surv., Chi. Acad. Sci., p. 328.

1903. Shells of Land and Water, Chicago. P. 22.

1906. A Catalogue of the Mollusca of Illinois. Bull. Ill. State Lab. Nat. Hist., VII, p. 92.

1911. Mollusks of Wellesley Island and Vicinity, St. Lawrence River. Nautilus, XXV, p. 67.

1916a. The Relation of Mollusks to Fish in Oneida Lake. Tech. Pub., N. Y. State Coll. For., Syracuse Univ., No. 4, p. 267.

1916b. The Freshwater Mollusca of Oneida Lake, New York. Nautilus, XXX, p. 8.

1918a. Further Notes on the Mollusca of Oneida Lake, New York; the Mollusca of Lower South Bay. Nautilus, XXXI, p. 87.

1918b. The Productivity of Invertebrate Fish Food on the Bottom of Oneida Lake, with Special Reference to Mollusks. Tech. Pub., N. Y. State Coll. For., Syracuse Univ., No. 9, p. 168 (many references to habitat in other places).

1918c. The Relation of Shellfish to Fish in Oneida Lake, New York. Loc. Cit., Circular No. 21. fig. 7, No. 22, 23.

1919. Mollusks infested with Parasitic Worms. Nautilus, XXXII, p. 97.

1924. The Fauna of the Lake Winnebago Region. Trans. Wis. Acad. Arts, Sci. & Lett., XXI, pp. 134, 142.

Beauchamp, W. M.

1880. Bythinia tentaculata Linn. Amer. Nat., XIV, p. 52.

1882. Bythinia tentaculata. Amer. Nat., XVI, pp. 244, 245.

1886. Land and Fresh-water Shells of Onondaga County and New York State. Baldwinville.

1891. Notes on Familiar Mollusks. Nautilus, V. p. 52.

Dall, W. H.

1881. American Work in the Department of Recent Mollusca during the Year 1880. Amer. Nat., XV, p. 716.

Daniels, L. E. (with *Blatchley, W. S.*).

1903. On Some Mollusca known to Occur in Indiana. 27th Ann. Rep. Dept. Geol. Nat. Res., Ind., 1902, p. 607.

Daniels, L. E.

1903. A Check List of Indiana Mollusca. Op. Cit., p. 641.

Latchford, F. R.

1914. Valvata piscinalis in Canada. Nautilus, XXVIII, p. 10.

1925. Bythinia tentaculata Linn. The Canadian Field Naturalist, XXXIX, pp. 41-43. (Review of supposed introduction and subsequent distribution of this species).

Letson, Elizabeth J.

1905. Check List of the Mollusca of New York. Bull. N. Y. State Mus., 88, p. 18.

Maury, Carlotta J.

1916. Freshwater Shells from Central and Western New York. Nautilus, XXX, p. 32.

Sterki, V.

1907. A preliminary Catalogue of the Land and Fresh-water Mollusca of Ohio. Proc. Ohio State Acad. Sci., IV, p. 386.

1911. Civilization and Snails. Nautilus, XXIV, p. 100.

Streator, Geo. J.

1889. Bythinia tentaculata, Linn., in Ohio. Nautilus, III, p. 46.

Walton, John.

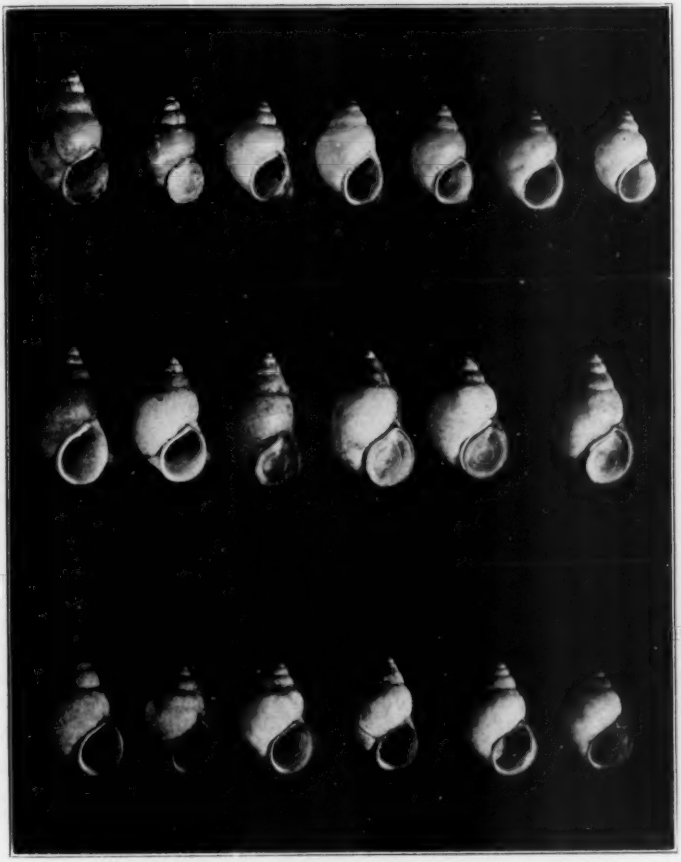
1891. The Mollusca of Monroe County, N. Y. Proc. Roch. Acad. Sci., II, p. 4.

Walker, Bryant.

1893. The Shell-bearing Mollusca of Michigan. Nautilus, VI, p. 139.

1911. A Check List of Michigan Mollusca. 13th Ann. Rep. Mich. Acad. Sci., p. 126.

1918. A Synopsis of the Classification of the Freshwater Mollusca of North America, North of Mexico., etc. Miscel. Pub., Mus. Zool., Univ. Mich., No. 6, p. 132.



DESCRIPTION OF PLATE

Upper row: Bithynia tentaculata (Linn.). Ditch, Scarborough, England.

Middle row: Bithynia tentaculata (Linn.), Variety. Lake Winnebago, near Oshkosh, Wis.

Lower row: Bithynia tentaculata (Linn.), Variety. Chicago, fossil deposit No. 1. Figures enlarged about two diameters.

GROWTH OF DIATOMS IN RELATION TO DISSOLVED GASES.

SAMUEL EDDY, UNIVERSITY OF ILLINOIS.

Periods of diatom abundance have been long known to occur during the colder months of the autumn and spring. Kofoid (1904) found this to be true of the diatoms of the plankton of the Illinois river with the exception of *Melosira granulata*. The latter reaches its greatest abundance during the summer months. Temperature was advanced by the earlier writers as an explanation for the greater growth during the colder months. Allen (1925) considered temperature to be an important factor in relation to the abundance of marine diatoms. Kofoid indicated that the spring and autumn floods were important factors as the heaviest abundance appeared after the overflows and did not occur when the floods did not appear at their usual season.

An increase in nitrates was noted by Whipple (1894) as an important factor in the increase of diatoms in reservoir waters. Whipple and Parker (1901) pointed out that while diatom abundance had been previously explained by an increase in the soluble nitrates, their occurrence in waters containing a large carbon dioxide content indicated a response to this gas. Diatoms have been shown by Palmer (1897) to produce oxygen and by Whipple and Parker to be carbon dioxide consumers. The latter also indicated that the autumn and spring growths of diatoms may be due to the increased circulation of the carbon dioxide as well as of the nitrates brought to the surface by the overturning of the larger bodies of waters. Pearsall (1923) advanced the theory that this semi-annual abundance was largely due to an increase in the dissolved oxygen content caused by the excessive rainfall. Pearsall further states that a deficiency of oxygen, nitrates, silica, or calcium is usually the limiting factor of diatom distribution.

Circulation caused by autumnal and vernal overturns and floods no doubt increases the mineral content of the water and adds to the dissolved gaseous content. The writer, however, has often observed periods of maximum

abundance of diatoms which could not be attributed to either of these causes. The majority of the periods of abundance of diatoms have been observed in the colder months, but periods of equal abundance have been noted in the warmer months when conditions were at the opposite extreme. Whipple and Parker have shown that the waters of ponds and streams dissolve a much greater amount of carbon dioxide during the winter months than during the summer months. During the colder season the bottoms of the shallow streams of Illinois are covered with a thick brown scum of Gomphonema which disappears during the spring floods. In the latter part of the summer during the period of low water and drouth, when the earlier aquatic vegetation begins to die and decompose, the carbon dioxide content of the waters is often high. During this season the great growths of Melosira and some Synedra often appear. This would indicate that carbon dioxide is a probable factor influencing the growth of diatoms.

With this factor in mind the writer conducted a series of experiments to determine the response of diatoms to carbon dioxide. Rich cultures of diatoms (mostly Synedra) were secured from scrapings of the bottoms of some laboratory tanks at the University of Illinois. In the following series, each of two cultures of diatoms were subjected to various amounts of carbon dioxide and oxygen for a period of several weeks.

Series 1—Cultures of diatoms through which CO_2 was allowed to bubble for twenty minutes every twenty-four hours.

Series 2—Cultures of diatoms through which a slow stream of air bubbled continually.

Series 3—Cultures of diatoms undisturbed.

Series 4—Cultures of diatoms into which water dripped, creating considerable aeration.

All cultures were placed side by side under the same conditions of light and temperature. Observations were made at the beginning and at the following intervals as described in the following table. The collections were made by stirring the contents of the culture and removing one cubic centimeter with a pipette. This collection was placed in a Sedwick-Rafter slide and the diatoms of a known area were counted, giving sufficient data for an estimate per

cubic centimeter. The results per cubic centimeter for the cultures of each series at the different periods of observation are as follows:

Days		1	2	8	12
Series 1	A	131,250	167,600	373,000	1,560,000
	B	120,750	147,000	2,100,000	24,000,000
Series 2	A	168,000	78,750	525,000	575,000
	B	210,000	184,800	630,000	627,000
Series 3	A	187,350	210,000	2,572,500	15,000,000
	B	210,000	210,000	3,202,500	25,000,000
Series 4	A	199,500	157,500	105,000	75,000
	B	131,250	52,500	26,250	30,500

A repetition of the experiments gave practically the same results. The diatoms of the cultures subjected to carbon dioxide (Series 1) showed an increase over those of all the other cultures except those of Series 3. The diatoms of the air cultures, (Series 2) showed only a slight increase during the first eight days, while those of the running water cultures (Series 4) decreased. This decrease may have been due to the removal of some of the diatoms by the water currents, but as the current was maintained at a very low rate, this probability was rather slight. The diatoms of the cultures (Series 3) which were undisturbed showed considerable increase in eight days. In these cultures there was evidence of decomposition of the organic matter, resulting in a high acidity and hydrogen-ion concentration. This indicating an abundance of carbon dioxide. The cultures showing the greatest increase in diatom growth were those of the series containing the greater abundance of carbon dioxide. The diatoms showed a greater growth response under the influence of the carbon dioxide than under the influence of oxygen. In the series containing the most diatoms the water was opaque. The diatoms were immotile and clustered together in large masses, especially on the twelfth day. Apparently their only reaction was that of growth. In the cultures of the air series the water remained clear, and the diatoms were quite active. In these cultures the diatoms exhibited general activity, but less growth response. In the cultures of the carbon dioxide series the accompanying Protozoa disappeared probably because of the toxic effect of the carbon dioxide, but were quite abundant in the cultures of the other series.

They probably destroyed some of the diatoms, but not enough to cause the resulting differences.

In the natural waters of Illinois the mineral content is probably sufficient for abundant diatom growth at all times. Turbidity, light, temperature, and dissolved gases are the more important factors involved in diatom distribution. In the spring following the melting of the ice, more light penetrates the water. The rising temperature increases the bacterial action upon the accumulated bottom debris, resulting in a greater carbon dioxide content. An abundance of carbon dioxide is an important factor for the growth of most diatoms. Not all diatoms react to the same factors or with the same degree of response. As with most organisms not one, but a combination of factors in the right ratio are responsible for the maximum development.

Bibliography.

Allen, W. E.
1923 Studies on Catches of Marine Phytoplankton made by Aid of the Kofoid Bucket. Ecology, IV (1); pp. 74-81.

Palmer, T. C.
1897 Demonstrations of Absorption of Carbon Dioxide and the Generation of Oxygen by Diatoms. Proc. Acad. Nat. Sci. Phila. pp. 142-144.

Pearsall, W. H.
1923 A Theory of Diatom Periodicity, Jour. of Ecol., XI: pp. 165-183.

Whipple, G. C. and Parker, H. N.
1901 Effect of Gases on Microscopic Organisms. Trans. Am. Micr. Soc., XXIII: pp. 103-145.

BIOLOGY AND HIGHER EDUCATION.

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My purpose is not to give reasons for the changes in courses of study relating to the biological sciences in high schools or to explain why higher education has neglected to keep pace with the demand brought by these changes but rather to give facts, whether liked or disliked, concerning the teaching of biology, botany, zoology, and physiology in high schools in the United States and call attention to the atttitude of universities, state normals, and teachers' colleges toward preparing teachers for the very popular subject, biology.

We shall first see just what changes have taken place in courses of study in the biological sciences in high schools within the last few years. G. W. Hunter, of Knox College, Galesburg, Ill., found in his study of secondary sciences for 1908 and 1923 that in 1908 there were 225 high schools teaching botany, while in 1923 there were 107 schools teaching botany; in 1908 there were 150 schools teaching zoology, while in 1923 there were 66 teaching zoology; in 1908 there were 193 schools teaching physiology, while in 1923 there were 73 schools teaching physiology; in 1908 there were 73 schools teaching biology, while in 1923 there were 299 schools teaching biology. The first three show a loss of from 30 to 50 per cent, while biology made a gain of 57 per cent. (See plate No. 1.)

Subject	Number Concerned		Per Cent Concerned		
	1908	1923	1908	1923	% of gain or loss
Botany	225	107	81.5	29.9	-51.6
Zoology	150	66	52.2	1.8	-50.4
Physiology	193	158	69	34.3	-35.6
Biology	73	299	26.5	83.5	-57.6

PLATE 1. Based on G. W. Hunter's study of secondary sciences in 1908 and 1923.

A study of Indiana high schools shows the following: In 1921 there were 80 high schools teaching botany, while

in 1926 there were 182 teaching botany; in 1921 there were no high schools teaching zoology, while in 1926 there were 18 schools teaching zoology; in 1921 there were 22 high schools teaching physiology, while in 1926 there were 83 schools teaching physiology; in 1921 there was 1 high school teaching biology, while in 1926 there were 290 schools teaching biology. (See plate No. 2.)

Subject	1921	1926	% of 646 schools 1921	% of 759 schools 1926
Botany	80	182	12.3	24
Zoology	0	18	0	2.3
Physiology	22	83	3.4	11.
Biology	1	290	.15	38.2

PLATE 2. Changes in five years in Indiana high schools.

The number of high schools in Illinois during 1926 teaching biological sciences were as follows: 63 teaching botany; 77 teaching zoology; 53 teaching physiology; 136 teaching biology. (See plate No. 3.)

Subject	Schools Teaching 1926	% of 663 Schools
Botany	63	9.5
Zoology	77	11.6
Physiology	53	8.
Biology	136	20.5

PLATE 3. High schools of Illinois in 1926.

In Ohio during 1926 there were 40 high schools teaching botany, a small number teaching zoology, and 1100 teaching biology. (See Plate No. 4.)

Subject	Schools Teaching 1926	% of 1375 Schools
Botany	40	3.
Zoology	Less than 40	?
General Science	?	75.
Biology	1100	80.

PLATE 4. High schools in Ohio, 1926.

In the high schools of Massachusetts, in 1925, we find few schools teaching botany; none teaching zoology; 250

or all teaching physiology; 165 schools teaching biology. (See Plate No. 5.)

Subject	Schools Teaching 1925	% of all schools
Botany	Few	?
Zoology	None	0
Physiology	250	100.
Biology	165	66.

PLATE 5. High schools in Massachusetts.

In our study of the courses of study of twenty states we find the % of biology taught in all high schools to be as follows: Ohio, 80%; Indiana, 38%; Illinois, 21%; New York, 95%; Pennsylvania, 76%; Delaware, 100%; Michigan, 90%; Kansas, 20%; Georgia, 90%; Wisconsin, 70%; Minnesota, 75%; California, 62%; New Jersey, 90%; Utah, 99%; Massachusetts, 66%; Florida, 60%; Nebraska, 20%; Arkansas, 80%; Oregon, 70%; Virginia, 100%. (See plate No. 6.)

State	% of Schools Teaching Biology
Ohio	80.
Indiana	38.2
Illinois	20.5
New York	95.
Pennsylvania	76.
Delaware	100.
Michigan	90.
Kansas	20.
Georgia	90.
Wisconsin	70.
Minnesota	75.
California	62.
New Jersey	90.
Utah	99.
Massachusetts	66.
Florida	60.
Nebraska	20.
Arkansas	80.
Oregon	70.
Virginia	100.

PLATE 6. Number of high schools teaching biology in twenty states, 1925 and 1926.

From the foregoing facts it is evident that biology is the most popular of all biological sciences; that biology has

been a part of the course of study of some states for many years and that biology is rapidly becoming a part of the course of study of other states such as Indiana and Illinois.

Certainly, the Universities, State Normal Schools, and Teachers' Colleges face the problem of training high school teachers in biology.

The author asked twelve representative institutions the following direct questions: first, does your school give a course or courses in general biology; second, does your school give a methods or a teacher's course in biology; third does your school give a major in biology. Plate 9 below is the reply:

Institutions	Courses in General Biology	Methods Course	Major
1. Stanford University	Yes	No	Yes
2. Northwestern University	No	No	No
3. Harvard	Yes	No	No
4. Cornell	Yes	No	No
5. Indiana University	Yes	Yes	No
6. Purdue University	Yes	No	No
7. Teachers' College, Macomb, Ill.	Yes	Yes	No
8. Ball Teachers' College, Muncie, Ind.	Yes	Yes	Yes
9. Chicago University	No	No	Yes
10. University of Illinois	No	Yes	No
11. De Pauw University	No	Yes	Yes
12. Yale	Yes	Yes	No

Eight of twelve higher institutions give a course or courses in general biology. From their catalog statement, they purpose to acquaint the student with fundamentals of living things. Six institutions out of twelve give the future teacher of biology a methods or teacher's course dealing with text books, courses of study, lesson plans, laboratory practice, laboratory equipment, etc. Four out of twelve offer a major in biology. That is, thirty-six term hours or twenty four semester hours consisting of varied combinations. Some have the major made up of botany and zoology; others have the major made up of general biology, a method course, botany, zoology and physiology. About one-half are neglecting to train in the most effective way a biology teacher. Too many students who are majors in botany or who are majors in zoology are going into high schools where they will face a course in biology. They may

not often know the biology of the house fly or may not know the biology of milk or biology of a hen's egg. They know little as to course of study, electing text books and biology outlook. A little modernism must come into the courses of study of many of our higher institutions. A few have taken the step.

Were I to suggest a course of study for a major in biology it would consist of a few courses in general biology, courses in botany, courses in zoology, a course in bacteriology, courses in human physiology, and a course in methods or the teaching of biology.

BIBLOGRAPHY.

Finley, C. W. 1926. Biology in the Secondary Schools and the Training of Biology Teachers. Contributions and Education; Teacher's College, Columbia University.

High School Biology in the United States. November, 1926. Turtox News. General Biological Supply House.

Indiana School Directory, 1920-1921 and 1926-1927.

Illinois School Directory, 1926.

Letters from State Supt. of Public Instruction.

Catalogs of Institutions.

Kinsey, H. C. 1925. Biological Sciences in our High Schools. Proceedings of Indiana Academy of Sciences, 1925.

COMMUNITIES OF MUSHROOMS.

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One that has observed the newspaper accounts of mushroom poisoning may have wondered why certain localities should have a great number of casualties while other localities are practically free from cases of mushroom poisoning. The reason for this is to be found in the study of the relationship between the topography of the land and the plant associations. Many of the cases of mushroom poisoning that come to our notice in the Chicago area occur from specimens gathered in the dune region. It is here that the Quercus velutina (Black oak) predominates and associated with this tree is a member of the Quercus velutina (Black oak) mushroom community called the Destroying Angel or Death Cup (Amanita phalloides). Nearly all of our very serious cases of poisoning in this area are the result of eating this one species.

Mushrooms may be classified into communities which are related to a corresponding association of higher plants. The dunes region, located adjacent to Lake Michigan, contains a succession of associations from the most xerophytic to the climax forest. Each of these has in it a community of mushrooms. The successional stages on the beach contain no mushrooms as the exposure is too great and the change too rapid to permit successful growth and reproduction. The higher plants are successful on the upper beach where the presence of Calamovilfa longifolia and Ammophila arenaria cause the moving sand to pile up and produce fore dunes. On these fore dunes along with these grasses is to be found a gregarious mushroom commonly spoken of as the "Lover of the Sand Binding Grass" (Psilocybe ammophila) and another called "Lover of the Sand" (Psilocybe arenulina). The presence of these mushrooms apparently in the midst of bare sand indicates that some organic material is present in the sand. By moving back farther into the dunes to a place where the sand has stopped moving and pine trees have established themselves another community composed of four or five species is to be found. This community is generally dominated by the Clavaria muscoides (Dingy

coral), Lepiota cristata (Small Scaly Mushroom) and Clitocybe pinophila (the Pine Loving Mushroom). Among these may often be observed the American Boletus (Boletus americanum), Granulated pored Boletus (B. granulatus) and rarely Lepiota cinnabarinus. If the pines have stood for a very long time Marasmius androsaceus (Pine needle Marasmius) and Mycena vulgaris will be found to have joined the community.

As pines do not succeed themselves the time eventually comes when they are replaced by an association of Black oak (Quercus velutina). Places where this has already happened may be found a little farther back from the lake. Here may be recognized a sandy soil with but little covering or in a very much protected spot a sandy soil with a thick covering of dead leaves. The communities of fungi are variable due to the differences in the amount of leaf covering present. The less protected locality where the leaf covering is very thin has a community composed of Geaster hygrometricus (Earth star), Tylostoma campestris (the Stalked Puff Ball), Scleroderma flavidum (Tough skinned Puff Ball), and Polyporus cinnamomeus (Silky Central Stemmed Polypore). Here areas become stabilized, but the protecting dune which by sheltering the area from the wind made possible the stabilization, shifts and the surface is again subject to wind action. The community that can live here is able to find subsistence in changing conditions. Stabilization becomes more permanent, gradually the leaf mould accumulates, and the humus is plentiful. The community of mushrooms increases in number and kind until the former community can no longer be recognized as a component part of the new community. This advanced stage, Black Oak community of mushrooms contains that beautiful yet dangerous monarch of mushrooms, the Destroying Angel or Death Cup (Amanita phalloides). This one species has been responsible for more human trouble than all of the other species combined and has claimed its toll of human life wherever the Black oak, Chestnut or other oaks that occupy the corresponding physiographic landscape exist. Others in this community are Hydnum zonatum (The zoned Toothed Mushroom), Tricholoma acre, T. transmutans, T. terriferum, Clitocybe ochropurpurea, T. personatum, Boletus felleus and B. edulis. In the protected

ravines away from the moving dunes where stabilization has long existed the association of trees is dominated by the Red Oak (Q. rubra) with an occasional Sugar Maple present to indicate that the next association is in the initial stage. Here the leaf mould is abundant and the herb life is an association of climax species. The community of mushrooms here found is exceedingly large. The sandy subsoil tends to insure an ever present supply of abundant moisture. Moisture and humus supply operate together as determining factors to augment the development of abundant carpophores. The number of fungi during a rainy autumn is tremendous. Among these may be enumerated Clitocybe maxima, C. caespitosa, Entoloma jubatum, Hydnum aurantiacum, H. repandum, Geaster rufescens and Inocybe repandum (Fiber head).

In either the xerarch or the hydrarch succession the number of fungi increases as the succession advances toward the climax stage. The dune succession presents the xerarch in which it may be noted that the humus supply becomes greater as we advance from one community to another of the series. A similar series of facts is in evidence in other xerarch successions such as the rock series or the change from a very open to a dense forest.

The bog succession is much richer in fungi than the swamp. The succession of vascular plant associations consists of a fringe of Decodon verticillatus (Whorled Loosestrife); Sphagnum, with other plants such as sundew and the pitcher plant; bog shrubs; Tamarack trees; Yellow Birch, Red Maple; and the climax Sugar Maple. These associations come in succession in time and quite often are arranged in place order due to the different degree of advancement of the habitats. In Cedar lake, Lake Villa, Ill.. for instance the zonation of associations is quite distinct composed of the fringe of Loosestrife well out in the lake perhaps 200 feet from shore. The next association forming a zone perhaps 100 feet wide is composed of sphagnum with other plants growing on the mat formed by the sphagnum. The entrance of shrubs on the sphagnum mat marks a third association. The communities of fungi do not here separate from each other with the same sharp zonation as is true of the vascular plants, in fact they seem to be determined more by the presence of the factors pro-

duced by the growth of the sphagnum rather than to the advance of conditions to a place where another vascular plant association may develop. On this mat of sphagnum is found a community of fungi composed of Omphalia fibula, Galera hypnorum, Hygrophorus miniatus variety sphagnophilus, Entoloma nidorosum, Hebeloma crustiliniforme form sphagnophilum and that most beautiful and colorful plant the Boletus spectabilis with its red and golden colors. All these seem to be related to the mat of sphagnum which forms most of the soil material for the growth of plants both vascular and nonvascular. The succeeding zone which contains Tamaracks (Larex laricina) contains two other fungi, Russula fallax and Lactarius sp. Cedar lake bog contains young tamaracks only. The indications here are that many years must elapse before the filling in of the lake by the accumulation of sphagnum in the form of peat will be sufficient for the advance to the Red Maple-Yellow Birch association. This stage of the successional advance has been reached in the Mineral Springs bog and with it has come a community of mushrooms containing some that belong in the preceding group and are to be associated with the Tamarack such as Boletus spectabilis, and the Vermilion Wax Gill (Hygrophorus miniatus) and in addition to these that have continued from the former community are Lactarius helvus, Cantharellus aurantiacus (Golden Vase), Calvatia saccatus (Bog Puff Ball), Hygrophorus speciosus (Beautiful Wax Cap) Collybia aquosa, Mycena sanguinolenta (Red milk Mycena), Gomphidius maculatus (Spotted Bolt) Lactarius camphoratus (Camphor Mushroom), and Hygrophorus chlorophanus (Yellow Wax Mushroom). The advance to the climax community finds a tremendous number of fungi as well as the remnants of bygone communities. These remnants furnish a most interesting means for the estimation of the past history of a habitat. If for instance we find in a climax forest the Yellow Wax Mushroom, Camphor Mushroom and Golden Vase, along with the usually expected climax forms. It seems justifiable to believe that they are remnants of a habitat that is different from the present one and that the habitat has developed to the climax through the bog series (hydrarch) rather than through a xerarch series.

A listing of the climax community shows the species of mushrooms to be much the same regardless of whether the climax has come through the one (xerarch) or the other (hydrarch) series. The percentage is doubtless as high as 80% but the differences between the two communities, the other 20% is of great interest from the standpoint of ecological development. Too little has been done on the problem of the estimation of past development from the differences to make any very sweeping conclusions. A few years further study of such relationships may bring forth more adequate data. In the forest at Tremont, Beech and Sugar maple are among the predominating trees but the association contains a community of fungi not only of the climax type but additional species associated with other stages of the bog successional series. Such evidence points toward a development through the hydrarch series in spite of the fact that the forest is adjacent to a xerarch dune series.

The two successions described serve to illustrate the successional advance of mushroom communities. Similar description of other successions would also show parallel successional advance of mushroom communities.

HUMANIZING SCIENCE TEACHING.

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I.

There are two outstanding types of poor teaching done by two types of teachers:

1. The first is a "teacher" who has little or no interest in either subject or in the student. This is of course the lowest form of teaching which does probably more harm than good, much like disinterested hired help in business who can run your trade "in the ground" in very short time. In education as in business, salesmanship is the essential quality that puts the thing over, in other words *education as well as goods must be sold by creating a desire to possess it.*

What a teacher of this type can do to a school is well illustrated by the following incident which came under my own observation some years ago in Pike County, Indiana in a country school house of the little red variety "on the hillside in the woods". For three years an enthusiastic teacher taught the school and in that time the interest of the community increased so remarkably that every available bit of space in the room was occupied by seats and chairs and the school was a beehive of life and industry. After the third year this teacher was promoted to the principalship of the schools of one of the smaller towns in the county and a new teacher came to teach the little school on the hillside. Now a great change set in; by the middle of the year the enrollment was exactly half of the other teacher's number the year before and by the end of the year she had about one third as many. Of course this was before compulsory attendance was in force but suppose it had been since the day of truancy laws what would have happened then? Beyond a doubt it would have been little better for the Community, because the majority would have attended under protest and their taste for education would have turned to nausea; and antagonism to the teacher would have made out of that room a place of contention and discontent.

I was personally much interested in this case because some of my own friends and acquaintances attended there and so I visited there one day and here is what I saw: The teacher, a young lady, sitting behind a small table, appeared half asleep, almost sullen in all her questions and remarks to the children, entirely without enthusiasm, no circumstance could seemingly induce her to smile and all in all she cast such a gloom over those children it gave one the impression she was dealing with two great evils, namely, the children and the curriculum of studies, that life was not worth living and the brats under her instruction were the worst ever wished on to any teacher since the profession was invented.

2. The second kind of poor teaching is caused by an over-estimation of the importance of the subject and a lack of interest in the student. Such a teacher will invariably dehumanize his teaching by regarding the learner as a sort of necessary evil in order that an opportunity may be found to teach *all* the important facts of the subject exactly as they appear to his own mature mind. He disregards the ability of the student to understand and fails to awaken an interest by giving the student some points of contact with his life's experiences and interests. Such a teacher is always a driver and never a leader of the young minds under his training.

II.

Now for two types of good teaching:

1. The highest type is that accomplished by a teacher who is interested in both his subject and the students. Such a teacher naturally senses the nature of every student individually and tries to connect up the subject with some human interest so that even the slowest ones can find it interesting to know something about it. This is the teacher who knows that a spark of interest must be kindled before the mind can have a desire to learn for in learning as in eating there must be a desire to partake or it simply will not happen. This teacher is essentially a leader instead of a driver *and blessed is he who can lead and need not drive.*

3. Another kind of good teaching is often accomplished by a teacher who has the proper human sympathies al-

though he may not have a first class knowledge of the subject to be taught. Such a teacher will, for the sake of the students, feel the responsibility to prepare the work well enough to achieve real results.

III.

Now in conclusion. How can teaching be humanized? It is, of course, easier said than done otherwise we could all do it and the teaching of Science would be like a picnic on a fine day or life at the edge of Paradise. The main point I believe is that cold isolated facts can be vitalized as a rule by connecting them up with some well known human interests as for instance in Chemistry the study of carbon or nitrogen and their compounds in relation to foods, poisons, plant growth, explosives, etc. In Biology the study of a fish or frogs, even their anatomy, can be related to human life both economically and structurally; their value to man is evident enough to the student and their structure is very much like that of our own bodies in many particulars and then their actions are really wonderfully like our own in response to stimuli upon the different senses.

Finally, what is teaching after all? I think we must agree that while some facts of knowledge must be imparted it is of far greater importance to arouse life interests which will remain and cause the learner to gather up more knowledge along the entire way of life.

A NEW FORM OF ECTOTROPHIC MYCORHIZA.

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Mycorhizas have many different forms and characteristics but certain types are limited to certain genera of trees. Mycorhizas of coniferous trees have characteristic forms that differ from those of deciduous trees though there are many variations in both cases.

The ectotrophic mycorhizas commonly found on deciduous trees have four parts. They are: (a) the fungus mantle, (b) a layer of cells that are elongated on one side of the root and irregular in shape on the other side, (c) about three rows of ordinary cortical cells and (d) the central cylinder. It is the area containing the radially elongated and irregular cells that is characteristic of deciduous trees. The fungus filaments penetrate between the cells in this region and enter the area of ordinary cortical cells. Usually, however, they penetrate only a very short distance into this area and sometimes not at all.

Mycorhizas found on coniferous trees have only three parts. These are: (a) the fungus mantle, (b) several rows of ordinary cortical cells and (c) the central cylinder. The fungus mantle is often not very well developed. The fungus penetrates between the cortical cells sometimes clear to the central cylinder.

The new form described in this paper was found on Quercus bicolor (see Fig. 1). Four regions could be distinctly seen in this form, namely: (a) the fungus mantle, (b) about five or six rows of ordinary cortical cells filled with a substance of some kind, (c) several rows of ordinary cortical cells not filled with the substance and (d) the central cylinder. This form of mycorhiza has characteristics of mycorhizas of both coniferous and deciduous trees. The fungus mantle is very well developed, unlike the mycorhizas of coniferous trees but similar to those of deciduous trees. However, the fungus filaments are not able, under any conditions, to penetrate the cells of the cortex. A close examination with the oil emersion microscope proved that the fungus did not gain entrance in a single case. Apparently the deposit in the outside area of cortical cells served

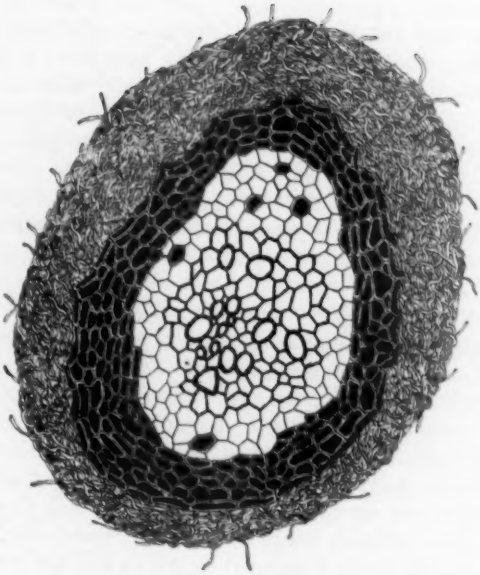

Fig. 1. Cross section of mycorhiza of Quercus bicolor

as a barrier that would not permit the fungus to enter. The central cylinder and the ordinary row of several cortical cells are the same as is usually found in other forms of mycorhizas.

It is necessary for the fungus to obtain nourishment from some source and the question confronts us as to where it has received enough nourishment to produce such a well developed mantle. It is rather doubtful that enough nourishment could be obtained from the outer row of cells of the root. There is a possibility that the fungus penetrated the younger portion of the root nearer the tip, and the mantle then grew back over the older portion of the root but was unable to enter the tissues. Whatever the case may be, it is quite evident that the fungus was unable to enter the root at that particular place from which the section was taken, and this seems to have been due to the unusually large amount of secreted substance in the cells. It is common to find this substance (probably resin or tannin) in a few cells of a mycorhizal root but not in such large amounts.

This phenomenon adds evidence in favor of the contention of McDougall[1] and some other workers that the symbiosis represented by ectrotrophic mycorhizas is antagonistic in nature. It is apparent that the fungus is parasitic on the tree but there is no evidence that the tree is parasitic on the fungus. On the other hand, such evidence as we have points to an attempt on the part of the seed plant to exclude the fungus. Mycorhizas have not previously been collected from Quercus bicolor and much more work needs to be done before definite conclusions can be drawn but the evidence from this one collection indicates that this species of oak is apparently able to "throw up a barrier" to prevent the penetration of a mycorhizal fungus and this may be a clue to the reason why some seeds plants form mycorhizas and others do not, that is, some may be more efficient than others in protecting themselves from the mycorhizal fungi.

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[1]McDougall, W. B., Mycorhizas of Coniferous Trees. Jour. Forestry 20:255-260. 1922.

THE VENUS-FLYTRAP (DIONAEA MUSCIPULA ELLIS.)

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In limited areas of the coastal regions of North Carolina and South Carolina grows a curious little plant which is found, in a state of nature, no where else in the world. This is the Venus-Flytrap (Fig. 1), so called because the blade of each leaf is modified into a trap by means of which insects of various kinds are caught. The generic name, Dionaea, is derived from that of Dione, the mother of Venus. The plant was first discovered by John Bartram about 1765 and specimens of it were sent by him to England where it was described and named by John Ellis.

The Venus-Flytrap is perennial by an underground stem and has fibrous roots. The leaves which are one to six inches long and partly succulent are all basal and so closely imbricated below as to form a bulb-like structure at the surface of the soil. The petioles are broadened by lateral wings and are the chief photosynthetic organs of the plant. At the upper end the petiole is abruptly contracted to a narrow, short stalk to which the blade is attached. In early summer a naked and usually unbranched scape from three to fifteen inches tall, which bears an umbel-like cluster of greenish white flowers, is produced.

The leaf blade consists of two semicircular lobes with a stout midrib between. The margin of each lobe is fringed with cilia-like teeth and on the upper surface of each lobe are three long hairs which are very sensitive to mechanical stimuli. When one or more of these hairs is touched by an insect, or anything else, the lobes come together quickly, the marginal teeth interlocking like the fingers when one's hands are folded, and the insect is held a prisoner. This closing of the trap, to be sure, is not so nearly instantaneous as is that of a man-made steel trap. The movement is a turgor movement, that is, it is due to a sudden change in the water content of certain cells along the midrib. This change in the turgidity of the cells causes the blades to move as though they were hinged to the midrib. It is the same sort of movement as that of the leaves and leaflets of the sensi-

tive plant and the rapidity of movement is quite comparable to what is frequently observed when a sensitive plant is subjected to a mechanical stimulus. In spite of the moderate rate of closing the insect seldom escapes being caught since the marginal teeth, which are incurved to begin with, are quickly brought close enough together to prevent it. Figure 2 shows that the sensitive hair consists of a definite stalk and an elongated distal portion. Just what makes this hair so sensitive and how the stimulus is transmitted to the cells along the midrib are matters that cannot as yet be adequately explained.

Scattered over the upper surface of each lobe of the trap are a number of short-stalked glands. When an insect is caught in the trap these glands are stimulated to secrete protein digesting enzymes and the digestible portions of the insect are thus rendered soluble and are absorbed and used by the plant. After the insect has been digested and absorbed the trap slowly opens again in preparation for the next victim. The whole process, from the time the insect is captured until the trap has opened again, may require two or three days, but several of the traps may contain insects, in different stages of digestion, at the same time, while some others on the same plant will usually be found open. This sort of interrelation between the plant and insects is known as antagonistic nutritive disjunctive symbiosis.

The Venus-flytrap occurs in a savannah type of vegetation where it is a minor element from the ecological point of view but forms societies of greater or less extent. The habitat is somewhat comparable to that of northern bogs. The soil is sandy and mildly acid. Soil acidity tests made in a flytrap society at the edge of a long-leaf pine forest in August, 1926, gave a Ph. value of 6.0. The soil is underlain by a non-draining subsoil and, while the water table may be at or above the surface during portions of the year, the soil may become very dry at other times. All of the plants of the community show xeric tendencies. This is shown in the flytrap by its succulence and by the fact that it has persistent, thick-walled root-hairs. No mycorhizal fungi have been found in connection with the roots of this plant.

The habitats to which this plant has become adapted are of limited extent and the plant is not extending its

geographic range, so that, if these habitats should be destroyed or materially changed, the Venus-flytrap would undoubtedly become extinct.

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Fig. 1. The Venus-flytrap.

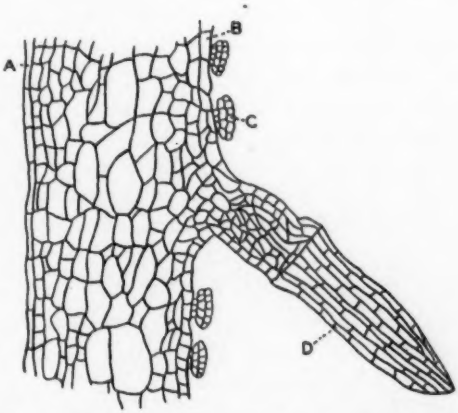


Fig. 2. Cross section of one of the lobes of the trap-like leaf showing one of the sensitive hairs and four glands. A. Lower epidermis. B. Upper epidermis. C. Enzyme-secreting gland. D. Sensitive hair.

A STUDY OF THE ALGAE OF A FRESHWATER STREAM

W. G. SOLHEIM AND W. T. PENFOUND.

The algae of the state of Illinois have received little attention from investigators. The most extensive investigations are undoubtedly those of Transeau on the algae of Charleston and vicinity. Eddy (1925) has studied to some extent the algal succession of a stream in various stages of development near Muncie. No other definite study of any given area has been made. Since algae form an integral part of any flora it seems strange that more attention has not been given them.

The investigation here recorded deals with a small freshwater stream which empties into the Salt Fork river just north of Urbana. The stream consists of a lower cutting portion with a fairly rapid current and an upper portion in which there was little or no movement, formed by log dams. The stream is fed by springs keeping the water fairly fresh at all seasons.

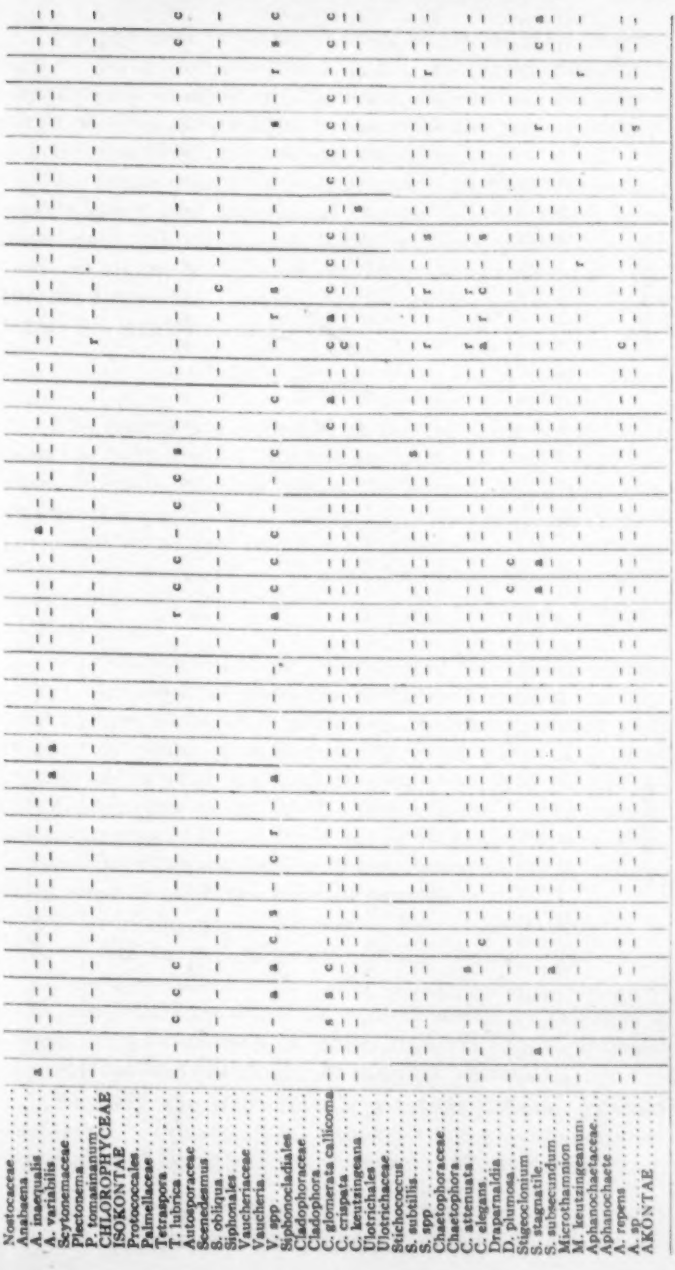
During the dry period of the summer of 1926 the lower part of the stream completely dried up for about a week. Later on during the periods of abundant precipitation the water rose so high as to practically wash out the majority of the algae. However the algae were soon present again in great abundance following periods of this nature. Such periods were always of short duration.

Collection and Identification of Algae.*

Collections of algae were made between April 13, 1926 and April 1, 1927. In all collections were made on twenty different dates, at least one being made every month with the exception of January. In order that the collecting should not be entirely indiscriminate the stream was divided into stations on the basis of varying conditions. Repeated collections were then made from each station on the dates recorded in the table.

*The authors wish to express their appreciation to Dr. Stella M. Hague for aid in determination of some of the forms.

| | Running Water | | |


Nostocaceae
Anabaena
A. inaequalis
A. variabilis
Scytonemaceae
Plectonema
P. tomasinianum
CHLOROPHYCEAE
ISOKONTAE
Protococcales
Palmellaceae
Tetraspora
T. lubrica
Autosporaceae
Scenedesmus
S. obliqua
Siphonales
Vaucheriaceae
Vaucheria
V. spp
Siphonocladiales
Cladophoraceae
Cladophora
C. glomerata callicoma
C. crispata
C. keutzingeana
Ulotrichales
Ulotrichaceae
Stichococcus
S. subtilis
S. spp
Chaetophoraceae
Chaetophora
C. attenuata
C. elegans
Draparnaldia
D. plumosa
Stigeoclonium
S. stagnatile
S. spp
Microthamnion
M. keutzingeanum
Aphanochaetaceae
Aphanochaete
A. repens
A. spp
AKONTAE

	Running Water																			Stagnant Water																	
	1926													1927			1926																		1927	
	Apr. 13	Apr. 20	Apr. 27	May 4	May 11	May 18	May 28	June 8	June 17	June 23	July 7	July 20	Aug. 17	Sept. 20	Oct. 12	Nov. 16	Dec. 16	Feb. 8	Mar. 11	Mar. 31	Apr. 13	Apr. 20	Apr. 27	May 4	May 11	May 18	May 23	June 8	June 17	June 23	July 7	July 20	Aug. 17	Sept. 20	Oct. 12	Nov. 16	Dec. 16	Feb. 8	Mar. 11	Mar. 31
Conjugales																																						
Zygonemaceae																																						
Mougeotia		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M. spp.																																						
Spirogyra		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S. porticalis																																						
S. weberi																																						
S. hasallii																																						
S. spp.																																						
Desmidaceae																																						
Closterium																																						
C. moniliferum																																						
C. acerosum																																						
C. spp.																																						
Mesotaenium																																						
M. sp.																																						
STEPHANOKONTAE																																						
Oedogoniales																																						
Oedogoniaceae																																						
Oedogonium																																						
O. spp.																																						
HETEROKONTAE																																						
Heterococcales																																						
Tribonemaceae																																						
Tribonema																																						
T. bombycina																																						
T. spp.																																						

For purposes of determination of species it was necessary to bring the collections to the laboratory since field identification of algae is practically impossible. Only in a very few cases can an algae be placed in the genus to which it belongs without microscopic examination.

All forms found have been placed in their respective genera and a good number of specific determinations have been made. However, the latter was not possible in all cases as all the algae were not at the stage necessary for specific diagnosis. Time did not permit the culture of these forms for identification purposes.

Results.

The results are imbodied in the following table. This table has been divided into two sections, the first listing the algae found in running water, the second, those found in stagnant water. Their frequency throughout the period is designated as follows: (a) abundant, (c) common, (s) scarce, (r) rare, and (—) none found. West's scheme of classification has been followed and the algae are listed according to it.

An examination of the table reveals several interesting things. In the first place the number of species and the total number of algae is greater at all seasons of the year in stagnant water than in running water. This is natural enough and is what one would expect. Also, it is quite probable that several of the species found in the running water are not normally found there but in this case have washed in from the stagnant portion of the stream and were caught in passage through the running portion.

Most of the species present in the running water were also present in the stagnant portion. Usually they were much more abundant in the latter place. A few forms, however, were more abundant in running water as *Tetraspora lubrica*, *Stigeoclonium* spp., and *Vaucheria* spp. *Drapernaldia plumosa* was found only in running water.

Secondly the table reveals a rather definite seasonal succession. Transeau[1] in treating of the periodicity of algae divides them into six groups: 1. Winter annuals, 2.

[1]E. N. Transeau. The periodicity of freshwater algae. Am. Jour. Bot. 3:121-133. 1915.

Spring annuals, 3. Summer annuals, 4. Autumn annuals, 5. Perennials and 6. Ephemerals. This same grouping is made use of here as far as possible. The significance of each group is made clear by consulting the table when species are referred to it.

In grouping the algae as indicated above a single species may be considered alone or all the species belonging to one genus may be considered collectively. In some cases as in *Spirogyra* and *Oedogonium* only the latter can be done as specific determinations were rarely possible.

Taking the species of *Oscillatoria* collectively the table shows that they are spring and early summer perennials. In other words the genus *Oscillatoria* is represented throughout the year but the greatest number of species and also total number occur between the middle of April and the first part of July. Considering individual species, *Oscillatoria limosa* is a winter annual, *O. tenuis* a spring annual, *O. princeps* a summer annual or perhaps a summer perennial. Several species are ephemerals while others appear to be spring annuals but cannot be definitely classified as such until more evidence is secured.

The fluctuations in abundance of a single species from date to date is largely due to flooding as previously mentioned. Flooding is a very important factor in determining the distribution and local abundance of algae.

A striking difference is shown between the seasonal abundance of *Spirogyra* spp. and *Oedogonium* spp. *Spirogyra* spp. collectively are winter perennials while *Oedogonium* spp. are summer perennials. In the early spring *Spyrogyra* is the predominant form and in the summer *Oedogonium* is largely the predominant form. Following the predominance of *Spirogyra* spp. and overlapping them and *Oedogonium* spp., *Oscillatoria* spp. especially *O. limosa* and *O. princeps* are largely the predominants. *Mougeotia* spp. and *Tribonema* spp. were associated with the *Spirogyra* spp. as sub-predominants in the seasonal succession.

Although all the species found cannot be definitely collected into perodicity groups the table suggests the following grouping:

1. Winter annuals; *Oscillatoria limosa, Tetraspora lubrica, Stigeoclonium stagnatile, Spirogyra porticalis,* S. spp. and *Tribonema* spp.

2. Spring annuals; *Oscillatoria geminata, O. tenuis, O. acuminata, O. chalybea* and *Spirulina major.*

3. Summer annuals; *Oscillatoria princeps* and *Oedogonium* spp.

4. Perennials; *Merismopedium convolutum* and *Cladophora glomerata callicoma.*

5. Ephemerals; The remaining species either fall into this group or else the evidence is such that it is at present impossible to place them in any particular group.

Summary.

1. The distribution and seasonal succession of algae in a freshwater stream consisting of a lower portion with running water and an upper portion with stagnant water near Urbana, Illinois has been studied.

3. The algal flora of the running water differed from that of the stagnant water in that the total number as well as the variety of species was much smaller in the former case. A few species of attached forms were more abundant in running water than in stagnant water.

4. The annual succession of algae was definite and often very striking, the flora being almost completely changed in relatively short periods.

5. Some algae are of long duration, whereas others are very abundant but only for short periods. On the basis of their periodicity, the algae have been grouped as winter annuals, spring annuals, summer annuals, perennials, and ephemerals.

6. Flooding was one of the greatest factors in the distribution of the algae, especially in the lower part of the stream.

THE FLORA OF THE RIGHT OF WAY OF THE ILLINOIS CENTRAL RAILWAY:

Waddams to East Dubuque.

H. S. PEPOON, M. D. LAKE VIEW HIGH SCHOOL, CHICAGO.

The author has traversed various portions of the territory covered by this paper, and during two summer vacations, walked the line from Waddams to East Dubuque, and from East Dubuque to Waddams.

It is to be taken for granted that this trip of about fifty miles was not made in one day, but, as it were, by the relay method. To illustrate the procedure, an early morning train was taken to Portage, some 16 miles from East Dubuque, and from 9 to 4 occupied in walking this portion. Another time, the Burlington train dropped three of us at Galena Junction (just across the Galena River from Portage), at 3:30 A. M., and our trip then extended until darkness overtook us in the outskirts of the western terminus; so by similar stages, back and forth, at various seasons, the ground has been thoroughly explored.

A somewhat extended statement is necessary to give a clear idea of why this stretch of railway was taken as a plant survey area. The Illinois Central was built from Freeport to East Dubuque in and near the year 1858, long before much of the land was under cultivation, and while 90 percent of the forest lands were as yet uncut. This one factor accounts for such features as small areas of "Original Prairie", something very hard to find in these days—undisturbed and unpastured *marsh lands*—bits of *original cliff* and steep *ravine sides*—*slough* remnants on the Mississippi bottoms—a portion of a western sandy plain epitomized in N. W. Illinois by a northward extension of the noted Sand Prairie of Jo Daviess—Carroll county.

Along the Galena and Mississippi Rivers are numerous places where deep and rugged ravines, and great jumbled rock masses or cliffs afford for all time, havens of refuge for many rare plants, simply because the section men, however laudable their desire may be to keep neat and clean the right of way, cannot mow or burn such spots. This

burning business is a dire catastrophe for many plants. The writer tried to induce the Illinois Central in the days of Mr. Wallace, to permit certain *placarded* areas to go unmowed and unburnt. The Railroad's answer was "No", because of fire hazard to surrounding farm crops. Certain of the marshes and ponds, and slough margins are too wet either to mow or burn. Here then, are the last stands of many notable plants. Long may it be before the ponds dry up.

Waddams at our eastern limit, is on the highest peak of the right of way, something like 1014 feet in elevation, and this "1000 feet" continues for some seven miles to Warren. The surrounding region is Glacial Drift, with many undrained prairie marshes, small ponds and with a gently rolling surface. Some five miles to the west, between Nora and Warren, the driftless area is entered. This first section is entirely prairie, and contains some ten restricted areas that may justly be termed "original."

From the margin of the Drift to the vicinity of Apple River, the marginal region of the Driftless Area is passed over. The land is high and rolling, with numerous hollows and from the earliest days, was almost entirely without trees, except along the creeks, with an elevation well above 900 feet. There are some high dry knolls west of the head waters of Clear Creek, with the bed rock but a few feet below the surface. The railway cuts miniature canyons through this limestone.

From Apple River west for some distance, wooded areas occur, succeeded by more open country which culminates in the famous Law's Cut, a mighty gouge in the Maquoketa Shales. Before reaching the cut, the small west branch of Apple River is crossed. This occupies its preglacial channel in a broad flat valley. We are now fairly in the hill land of Mill creek, Hell's Branch and East Fork of the Galena River and down the last named stream, in tortuous course, midst ever heightening hills, the road wends out upon the alluvium of Galena River, past the ancient lead mine city of Galena on its bluffs and slopes and with one last swinging curve out to the bottom lands of the Mississippi.

From Portage to East Dubuque, the towering bluffs and cliffs are on the right, broken by three river valleys; and to the left, the sloughs, bayous, swamps, bottoms and waters of the great river. So narrow is this strip of land in places that the two other railway lines run their trains over the Illinois Central tracks, there being no room for more. Beyond Portage are many steep wooded slopes abutting on the right of way, numerous ravines, and for some distance, a wonderful palisade of towering lime stone cliffs. After crossing the Little Menominee River, the double tracks separate, the south or east bound passing through the sandy barren before mentioned, joining some two miles east of the western goal. From start to finish, the rails have pursued every direction of the compass except north and east, thus giving every manner of exposure. With the exception of about three miles, the whole distance has been in Jo Daviess Co., and for four miles, just south of the Illinois-Wisconsin Line.

With the above as a working stage, let us investigate the plants of the right of way. The author has a list of 1211 plants found in the county, every part having been repeatedly covered. On the area under consideration, 605 species have been recorded, or exactly one-half lacking one. Truly a remarkable showing.

It may be of interest to tabulate a few groups before considering some of the rarer and more choice forms that here are finding their last hope of existence in the whole county.

There are 110 examples of good and genuine weeds. This is no slander upon the zeal of our section men, for be it known, there is no place like a railway for such an exhibit. Many of these are tramps, pure and simple, and lead a precarious life, season by season, each year with a somewhat different combination. Such are the three wild four o'clocks, (Oxybaphus); numerous spurges (Euphorbia); the lance-leaved sage (Salvia lancifolia); two Chenopodiums, the Jerusalem oak and Mexican tea, the Cotton plant, Silver orach (Atriplex argentea); Flax, rape, turnip, wheat, oats, rye, barley, and alfalfa represent our cultivated plant group. Cow-herb (Vaccaria) is a showy example of a tramp weed.

Among these tramps are a few that cannot be considered weeds, at least with us. The western gum weed or tar weed (Grindelia squarrosa) is found here and there; the showy evening primrose (Oenothera speciosa) rarely occurs; the hoary night-shade (Solanum elaeagnifolium); Froelichia; Scarlet gaura (Gaura coccinea); the wild potato vine (Ipomoea pandurata); Petunia; tomato; hop clover (Trifolium procumbens) are tramp plants of this character.

To summarize further, we find:

17	ferns
100	grasses
70	sedges
110	weeds
35	water plants
100	composites or members of the Aster family
40	shrubs
133	other plants
605	

Fifty-five species of trees adjacent to or leaning over the line fences may be referred to. These cannot perhaps be included in actual right of way plants but would be there but for the hand of man.

The ferns are found almost exclusively on the rocky portions of the right of way from Warren west. The rock brake (Pellaea) is more and more finding such rock cuts congenial dwelling places. Here also, the Woodsia thrives, and the dainty and interesting bulblet fern (Cystopteris). On the great rock-fragments the walking fern is occasional, and the ostrich fern forms small colonies on the low alluvium of creek borders. The flowering fern is at home on shaded banks and the very rare Feei cliff fern (Cheilanthes Feei) is overlooked on sun exposed cliffs.

The grasses and sedges are very abundant on all the marshy and prairie portions, as well as in the shade of the Mississippi bluff woods. There are 53 species of the genus Carex, 10 of Cyperus, 15 of Panicum. The only species that need special mention are wild rice (Zizania); purple love grass (Eragrostis pectinacea); blue joint (Andropogon furcatus); sand-binder grass (Calamovilfa); sand

grass (Panicum virgatum); the curious drop seed grass (Sporobolus heterolepis); the great cord grass (Spartina); two mesquite grasses (Bouteloua hirsuta and oligostachya); and the great Lyme grass (Elymus robustus).

A few water plants or wet marsh forms are worthy of comment. The western water lily; two yellow pond lilies (Nymphaea advena and rubrodisca); the yellow and white water crowfoots; an arrow head (Sagittaria latifolia) with a leaf and stalk 6 feet in length; the rare Lophotocarpus calycinus in an isolated flood pond near East Dubuque; five species of yellow and purple bladderworts (Utricularia); water willow (Decodon); the great swamp rose mallow (Hibiscus militaris); the water plantain (Alisma).

Some 12 trees that may with propriety be listed are: the canoe birch on the Mississippi bluffs; the yellow birch on the bottoms; the red cedar on the bald cliffs; at their base, the Kentucky coffee tree; the ashes, green, black, red and white in appropriate soils; the red mulberry on the lower part of the rich wooded slope; the king nut or bottom shagbark hickory on the dry bottoms; the black sugar maple and the rock elm, associates on rocky lowlands.

The shrubs are soon disposed of, for of the many, only a few need attention; the juniper is at home on the cliff-brows; the yellow bush honeysuckle (Diervilla) on the rocky banks; the genuine arrow wood (Viburnum dentatum) and now and then a wild snowball (Viburnum americanum) on a damp cliff; yellow and red honeysuckles are here and there; the shrubby cinquefoil (Potentilla fruticosa) delights in cool damp cliffs, where also the prickly gooseberry, the nine-bark (Physocarpus) and the American yew (Taxus) are to be found. Five species of Cornus or dogwood are often met with, the common one being the small white (Cornus paniculata). In the undrained swamps, buttonbush and many willows grow.

Of the herbaceous plants not included in the above, and numbering some 233 species, there are many very striking forms, a number of which have not been found in Jo Daviess Co. except along the Illinois Central Railway. Let us dispose of these first, without order but as they occur

from Waddams to East Dubuque. As will be noted, these plants are largely original prairie species.

Between Waddams and Nora are colonies of the palmate, larkspur and birdfoot violets; the early crowfoot (Ranunculus rhomboideus) and the white blue-eyed grass (Sisyrinchium albidum). Between Nora and Warren are many fine examples of the cream colored wild indigo (Baptisia bracteata), the Quamash (Camassia), the wonderful white fringed orchis (Habenaria leucophoea) in a blanket of white on the moist low prairie; the deep blue prairie gentian (Gentiana puberula), the most enduring and bluest of our species; the flesh colored milkwort (Polygala incarnata); and the prairie parsley (Polytaenia). Near Apple River is a fine collection of purple coneflowers (Brauneria pallida); the prairie dandelion (Agoseris); the yellow hop clover, and the spicate blazing star (Liatris spicata). West of Apple River are numbers of cream wild indigo and Valerianella (V. chenopodifolia); also great collections of the edible valerian.

Near Galena, by the side of the river, is a great patch of the glade mallow (Napaea), this having been found by the author in but one other locality in Illinois; the showy hedge nettle (Stachys tenuifolia); a red form of oxalis (O. rufa of Britton) always in wet rock cuts; the two colored skullcap (Scutellaria versicolor; Sullivantia and Zygadenus chloranthus or Camass. While found elsewhere, the lilies (L. superbum and philadelphicum) are far finer on the undisturbed soil of the railroad strip. The yellow lady's slipper occurs in many places, the small white form on Apple River only.

Along the stretch of road from Portage to East Dubuque are a number of fine plants. Here only do we find the beautiful Ipomoea before named and the rose mallow; twinflower (Jeffersonia); golden Corydalis; the long flowered Puccoon; the striking poppy mallow (Callirhoe involucrata); the white plains thistle (Cirsium undulatum); C. pumilum, the fragrant one, beloved by country children who plunder it for nectar, extends the whole length; at one place only is the great Rudbeckia (R. subtomentosa) found; the small white milkweed thrives at the

western limits, while the showy prairie species (Asclepias sullivantia) abounds at the eastern portion.

Much more might be said but enough has been presented to emphasize strongly the part our great railways, built nearly three-quarters of a century ago, have in conserving and preserving our fast diminishing company of choicer plants. Here many I have named are making their last stand before extinction. It is indeed a pity that some way cannot be found to enable the railroads to set apart here and there choice remnants of this vanishing flora, to be placarded and cared for by state or local societies, as some evidence of "the glory that once was."

In conclusion, I wish to thank the Illinois Central Railway for many courtesies extended in the past days, and for the use of their large scale maps which have been used in making the sectional maps of this paper. The railroad possesses the last rear-guard of the innumerable host of beauties that once made glad the Illinois lands. This is an asset not adding an iota to the dividend of dollars, but which, preserved to the flower-loving public who ride on its trains, will engender in the hearts of an increasing constituency, a kindlier opinion toward a so-called soulless corporation, that is thus able to blend with its great undertakings, a generous and fostering concern for the flower suppliants to be cherished or blasted by its decree.

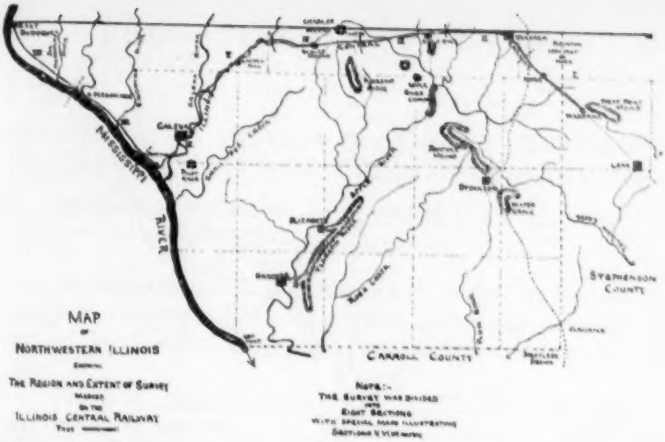


FIG. 1

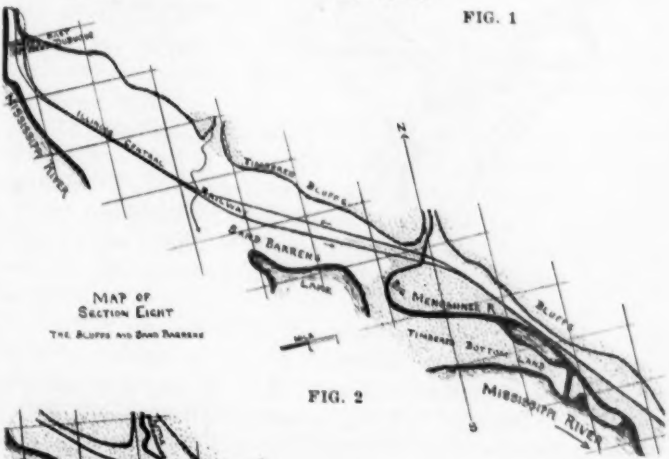


FIG. 2

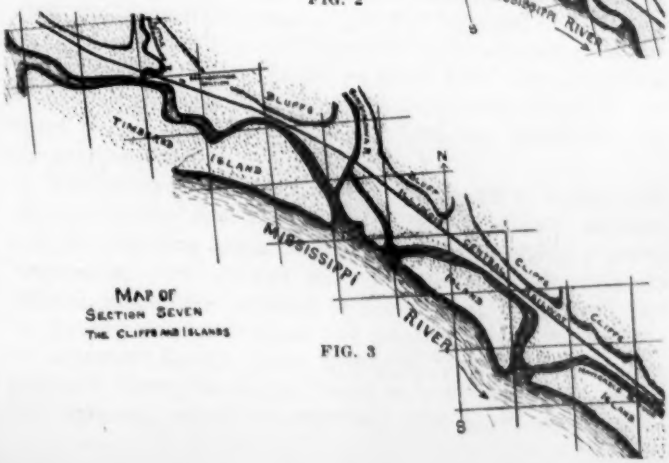
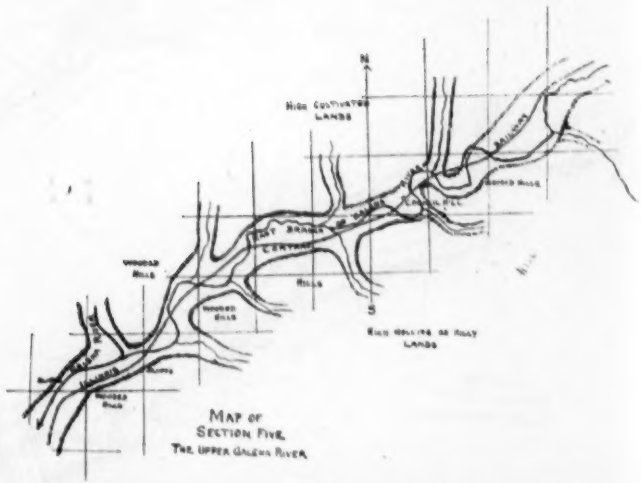


FIG. 3

MAP OF
SECTION SIX
THE LOWER GALENA RIVER

FIG. 4



MAP OF
SECTION FIVE
THE UPPER GALENA RIVER

FIG 5

THE EFFECT OF VITAMIN (B) AND (C) DEFICIENCY ON THE MECHANICS OF THE INTESTINAL TRACT.

BEULAH A. PLUMMER, SPRINGFIELD HIGH SCHOOL, SPRINGFIELD, ILLINOIS.

An experiment was conducted in order to determine whether deficiency diets materially affect the motility of the intestinal tract in beriberi rats and in scurvey guinea pigs.

There is according to Alvarez (1922) a definite rhythmic gradient in the intestine from pylorus to colon, the rate of rhythmic contraction varying from seventeen to twenty per minute in the duodenum to ten per minute in the lower ileum while the larger bowel is more sluggish than the small intestine.

The method of isolated strips as described by Alvarez (1922) was used in this experiment and comparisons of the normal with the experimental segments were made in rate of and amplitude of rhythmic contractions, tonus and duration, or the length of time during which the excised strips exhibit spontaneous contractions in oxygenated Locke's solution.

After decapitation the abdomen of the animal was quickly opened. A loop of intestine two and one half centimeters long was removed from the duodenum immediately below the stomach, the same length of terminal ileum and a similar portion of the colon about thirty millimeters above the anus. The remainder of the tract (with the exception of the caecum) was put into Petri dishes and placed on ice where the temperature registered from one degree to five degrees Centigrade.

The three isolated strips were suspended in a dish containing exactly one liter of oxygenated Locke's solution kept at a constant temperature of 38°C by means of a pencil thermostat. The oxygen was liberated through a glass cannula which was fastened to the bottom of the dish and the bubbles passed through the solution at the rate of ten per minute. Levers were arranged which recorded the rhythmic contractions and tonus on a kymographic paper. The leverage, length of arm, and load were not changed

throughout the course of the experiment so that the work and magnification were comparable. Preparations of both the normal and experimental animals were made in this manner and tracings were run from the refrigerated strips on the second, third and fourth days after removal from the animal. The normal animals were starved for forty-eight hours previous to the experiment to insure an empty alimentary canal.

Twenty-four rats were given B free diet. The ration consisted of casein (18) grams, starch (54) grams, lard (15) grams, butter fat (9) grams, and salts (4) grams. (Osborne & Mendel). The average time on this diet was seven weeks during which there was a gradual loss in weight and in general a marasmic condition. The number of feces decreased which seemed indicative of constipation. Five of the experimental animals developed a spastic gate at which stage they were killed for the experiment. Seven normal animals were used for controls.

As shown in Chart I the normal duodenums lived 148 minutes longer than the beriberi duodenums, the normal ileum 173 longer than the beriberi ileum while the normal colon exceeded the beriberi colon by 467 minutes. In every case tracings from strips of the intestine on ice were run on the second day; but not one of the beriberi segments showed motility on the second day while six of the normal duodenums were active, one of the normal ileums and seven of the normal colons.

The contraction rate was calculated for the first and third hours—Chart II. Both the normal and experimental duodenums contracted the first hour at the same rate, but the (B) deficient duodenums lost rapidly so that at the end of the third hour the normal was giving almost double the number of contractions. Even the first hour the beriberi ileum showed a decidedly lower rate than the normal and at the end of the third hour the beriberi ileum dropped to the zero point while the normal ileum was able to give 268 contractions. The two colons kept pace with only a difference of eight contractions in favor of the normal at the end of the third hour.

Chart III—The tonus factor showed a great variation in the number of waves, especially in the normal ileum and colon. In the duodenum the first hour, there were on the

average only two more waves, in the ileum 19, in the colon 16.

In the case of the ileum, the amplitude of the rhythmic tonus contractions averaged higher in the normal than in the beriberi strips. This was also true for the duodenum and the colon but here the difference in favor of the normals was less marked.

Excised intestinal segments of the beriberi rat showed no spontaneous contractions or tone after twenty-four hours on ice. Therefore, the endurance of the intestinal motor mechanism is doubtlessly impaired in Vitamin (B) deficiency since in every experiment the normal strips were active on the second day. Absence of Vitamin (B) from the diet of a rat diminished the length of time during which an excised strip exhibits spontaneous contractions in oxygenated Locke's solution. The amplitude and rate of the rhythmic contraction is markedly decreased in the spastic stage of the beriberi rat especially in the duodenal and ilial segments.

The same method was employed for testing the mechanics of the intestinal tracts in acute scurvy. Ten normal guinea pigs and nine scorbutic animals were used in the experiment.

The experimental guinea pigs were fed C free diet composed of oats and a mixture of alfalfa meal with wheat flour (equal parts by weight). When they had reached the stage of advanced scurvy they were killed. Due to a loss of appetite prior to death, the tract was usually empty except the caecum and sometimes the colon.

As shown in Chart IV—the first day there was no difference in the duration factor for the normal and scurvy duodenum but the normal ileum lived 18 minutes longer than the scorbutic. In the colon there was a difference of 50 minutes in favor of the normal strips. On the second day the normal duodenum outlived the scurvy duodenum by 185 minutes, the normal ileum exceeded by 134 minutes while the normal colon lived 81 minutes longer than the scurvy colon. The story for the third day is practically the same, since the normal duodenum lived 169 minutes, the normal ileum 167 minutes and the normal colon 165 minutes longer than the scorbutic strip. The fourth day the normal duodenum showed an average life of 65 minutes while none

of the scurvy segments showed activity. The normal ileum outlived the scurvy ileum by 16 minutes while the normal colon exceeded the scurvy colon by 105 minutes.

The scorbutic colons usually showed activity or survival for 96 hours, and in every experiment the length of time which the normal strips survived and contracted exceeded that of the scorbutic, not only on the first day but on the second, third, and fourth days after death.

Chart V—In determining the rate of rhythmic contractions for the first day, 1st and 4th hours, the normal duodenum contracted more rapidly than the scorbutic. The scurvy ileum showed a hypermotility. At the beginning of the first hour, the rate of the scurvy colon surpassed the normal but at the end of the fourth hour the record was reversed. On the second, third and fourth day the curves showed that the normal strips uniformily surpassed the scorbutic segments.

In computing the work based on the amplitude and number of rhythmic contractions for the first and fourth hours, the record showed that more work had been done by the normal segments than by the scurvy segments with the exception of the scurvy ileum for the first day, first hour. The records for the three succeeding days demonstrates the greater efficiency of the normal strips.

Chart VI and VII—A count of the number of tonus waves was made for the 1st and 4th hours; also the amplitude of these waves was measured in both the scorbutic and normal tracings for the four successive days. Tonus of the intestinal wall of the moribund scorbutic guinea pig showed a slight increase in the duodenum with a marked increase in the colon. However, there was a decrease in the tone of the scorbutic ileum.

In estimating the number of duodenum, ileum and colon segments which were capable of spontaneous activity and tone during the four successive days, the percentage was much higher for the normal than for the scorbutic strips.

In the scurvy guinea pig, we found in general that the colon showed initial hypermotility. The colon of the animal with most advanced scurvy gave the highest amplitude of rhythmic contractions, three of them reaching 97, 95 and 90 millimeters while the highest amplitude recorded for the normal colon was 87. Extreme amplitudes were also noted

in a guinea pig showing practically the same degree of scurvy.

If the autonomic activity of the intestinal strip as recorded by the method herein employed is a true index of the physiological condition of the local intestinal motor and muscular mechanism, we may conclude that deficiency of Vitamin (B) on the whole diminishes the motility both in amplitude and rate of contractions and shortens the time during which excised strips exhibit spontaneous contractions. Deficiency of Vitamin C likewise shortened the duration of the excised strip and diminished the rate of rhythmic contraction with the exception of the ileum the first hour of the first day, but tonus and amplitude of rhythmic contraction were increased.

According to the results of this experiment, deficiency of Vitamin (B) affects the mechanics of digestion since stasis and hypomotility seem to characterize the beriberi intestinal tract. Lack of Vitamin (C) decreased the duration of the strips also diminished the rate of rhythmic contractions; but the increased amplitude of the rhythmic contractions indicated hypermotility in the colon and also some hyperactivity in the duodenal strip. The tonus of the intestinal wall was considerably increased in the scorbutic strip.

In comparing the effect of deficiency of Vitamin (B) with the effect of deficiency of Vitamin (C) on the activity of the digestive tract, it would appear that the effects are opposite. Lack of (B) causes a decrease of activity with retention of the intestinal contents while lack of (C) does not interfere with peristaltic digestion to as great a degree. However, the results seem to indicate a speeding up of motility in the acute moribund stage.

In as much as the beriberi strips of the rat and the scorbutic strips of the guinea pig were unable to show motility as long under the same experimental conditions as the normal, the experiment indicates that the mechanics of digestion are involved in both the deficiency of Vitamin (B) and (C). However, the effects on motility in (B) deficiency may be quite different pathologically from the effects of (C).

Bibliography.

1. Alvarez, W. C.—Mechanics of the Digestive Tract, 1922.
2. McCarrison—Studies in Deficiency Diseases, 1921, pp. 86-122.
3. Gross, Lewis—The Journal of Path. and Bact. Vol. XXVII, 1924.
4. Bayliss, W. M. and Starling, E. H.—Journal of Physiology, Vol. XXIV, 1899, p. 99-143.
5. Cowgill, R.—American Journal of Physiology, Vol. 77, 1926.
6. Gunn, J. A. and Underhill, S. W. F.—Quart. J. Physiol., 1914, p. 275-296.

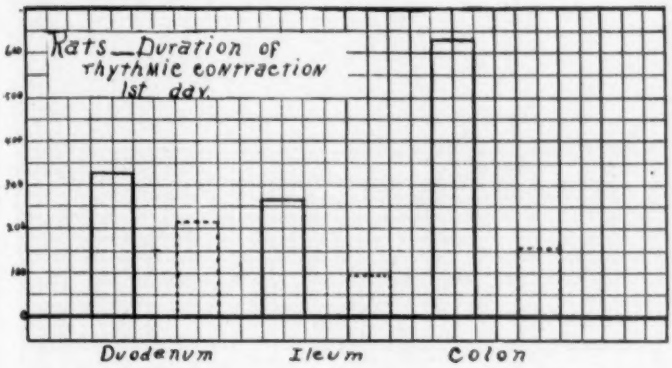


Chart I.—The length of time which excised strips can exhibit spontaneous contractions and tone in oxygenated Locke's solution is longer in the normal duodenum, ileum, and colon than in the polyneuritic segment. Normal——; Polyneuritic.....

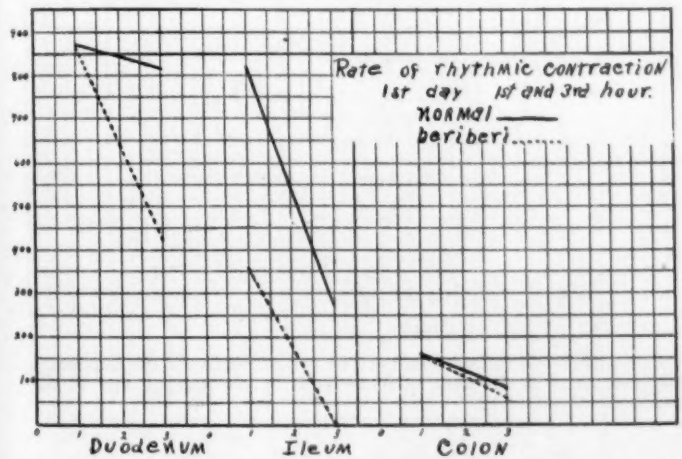


Chart II.—The rate of rhythmic contraction decreases rapidly in the duodenum and ileum segments of the polyneuritic rat. The rate of spontaneous contraction is lower in the polyneuritic colon and the decline gradual.

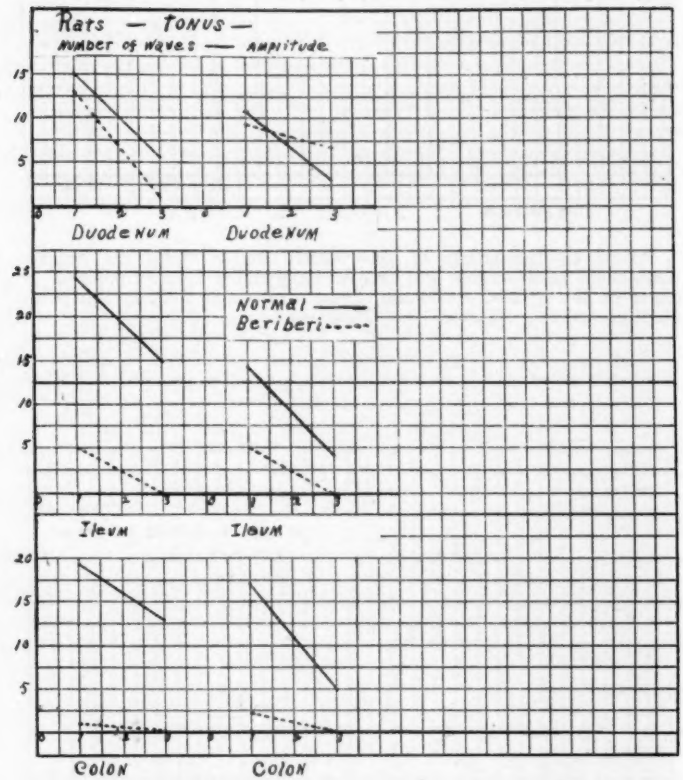


Chart III.—In the beriberi rat, the excised strips of the duodenum and colon show a decrease in tonus both in the number and in the amplitude of waves.

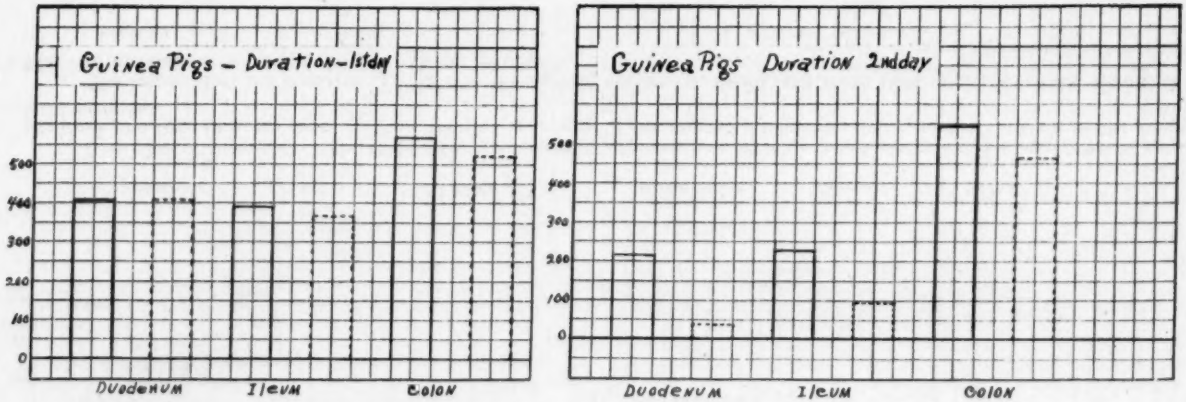


Chart IV.—The first day, the length of time during which excised strips can exhibit spontaneous contractions and tone in oxygenated Locke's solution is longer in the normal ileum and colon than in the scorbutic strip. There is practically no difference in the duration of the normal and scorbutic duodenal segments.

The second day, the duration is longer in the normal duodenum, ileum, and colon than in the scorbutic strip.

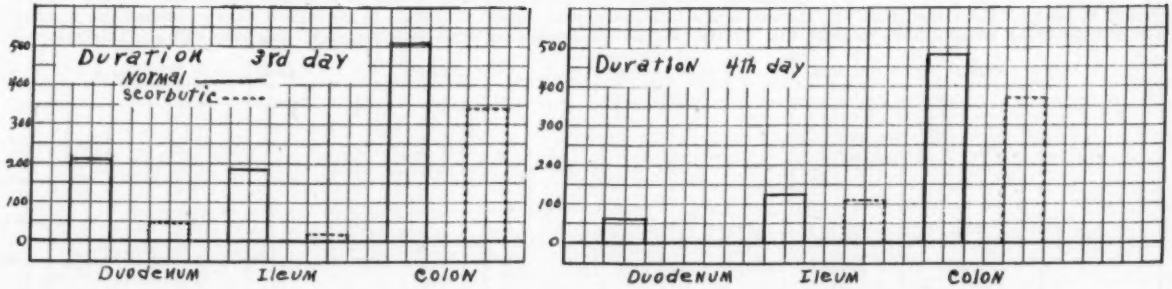


Chart IV (Continued).—The third day, the length of time during which excised strips exhibit spontaneous contractions and tone in oxygenated Locke's solution is longer in the normal duodenum, ileum, and colon than in the scorbutic segment.

The fourth day, the duration is longer in the normal duodenum, ileum, and colon than in the scorbutic segments. The scorbutic duodenal strips did not exhibit activity.

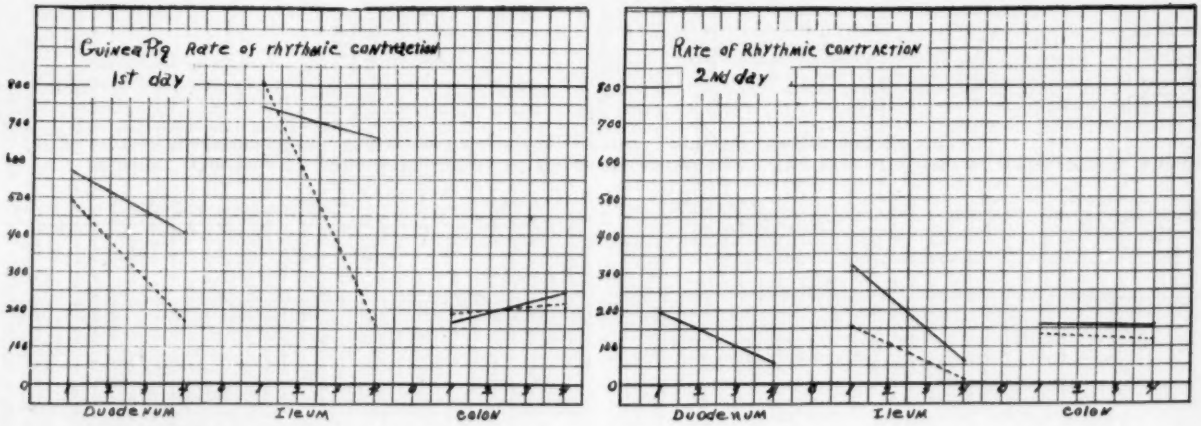


Chart V.—The rate of rhythmic contraction in the scorbutic duodenum the first day is lower than the normal. The scorbutic ileum exhibits hyperactivity with a marked decrease in rate. The scorbutic colon exceeds the normal in rate for the first hour. Normal———, scurvy.....

The second day the rate of rhythmic contraction is higher in all of the normal segments than in the scorbutic strips.

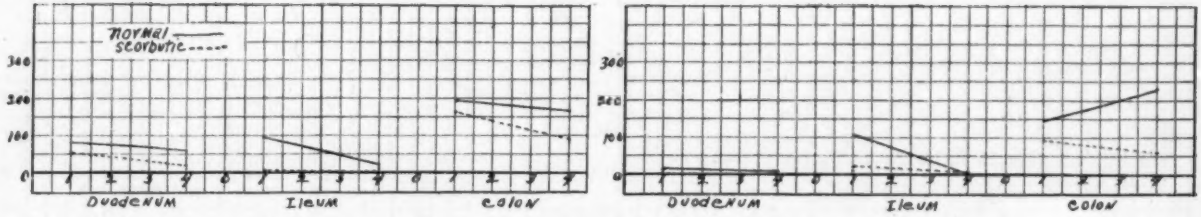


Chart V. (Continued).—Guinea Pig—Rate of Rhythmic contraction. The rate of rhythmic contraction is higher in the normal duodenum, ileum, and colon than in the scorbutic segments the 3rd and 4th day.

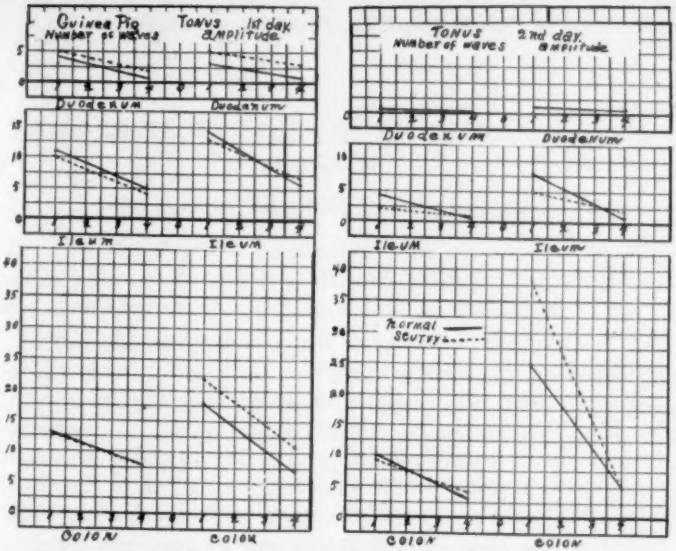


Chart VI.—The excised strips of the scorbutic duodenum and colon the first day show an increase in both number and amplitude of tonus waves for the first and fourth hours. The reverse is true in the scorbutic ileum.

The second day, the scorbutic colon showed marked hypermotility.

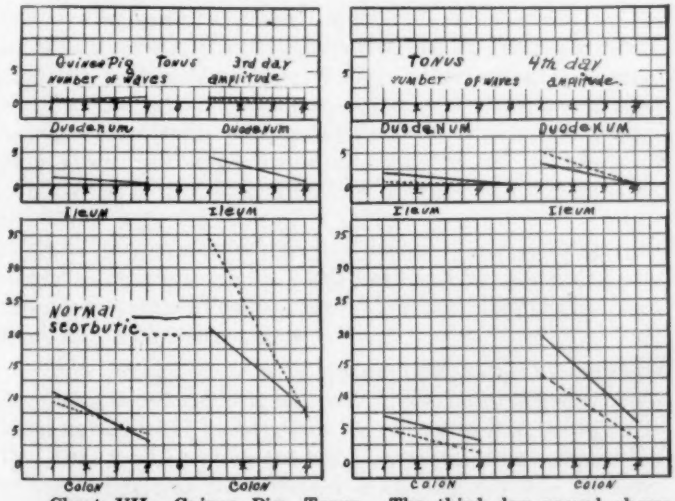


Chart VII.—Guinea Pig—Tonus. The third day record shows marked hypermotility in the scorbutic colon. There was no duodenal activity the fourth day. The normal colon strips showed more tone than the scorbutic.

THE LIGNEOUS FLORA OF RICHLAND COUNTY, ILLINOIS.

By Robert Ridgway, Olney, Illinois.

[The following is an abstract of a paper based on material collected during the years of 1914 to 1927, inclusive, and identified by the leading botanical authorities.]

Why investigation of the flora in certain parts of the United States has been so long neglected by botanists is little short of a psychological puzzle. The geographic distribution of plants is certainly an important part of botanical science; yet it is a common experience of local botanists to find that knowledge of this subject is very far from being exact. Two instances among the many that have been encountered by the writer will be sufficient to prove this assertion: Gray's "Manual" (seventh edition), Britton and Brown's "Illustrated Flora," and all other authoritative text-books on the botany of the Eastern United States that have been consulted, ascribe to *Viburnum dentatum* an extreme northeastern range, Michigan being given as its southwestern limit; yet that species has an extensive range over the central Mississippi Valley, occurring as far southward as the extreme southern portions of Illinois and Missouri; while *Malus platycarpa hoopesi*, which was known only from cultivated trees as recently as the date of publication of the second edition of Sargent's "Manual of the Trees of North America" (1922) occurs, rather plentifully, as an indigenous tree in Richland County, Illinois, as does also *M. angustifolia*, a southern species, not previously recorded (authentically) from farther northward than Pope and Johnson counties.

Few botanists seem to realize that natural conditions are changing so rapidly, not only in the more densely populated agricultural sections but also in parts less thickly settled, that it will soon be too late to ascertain the composition of the indigenous flora, indeed is already too late in many parts, where a greater or less number of the native plants are gone forever; others are so completely established by naturalization that it is now sometimes impossible to know

whether a species is really indigenous or not. The transformation of the country through deforestation, drainage, cultivation, pasturage, burning, and other agencies, the greater part of which has occurred within the memory of persons now living, is in some instances so profound that an individual born seventy-five years ago who left his home in childhood or early manhood would now scarcely recognize the country of his nativity.

The following remarks by Mr. Chas. C. Deam, State Forester of Indiana, will apply equally well to this portion, at least, of Illinois:

"The acquisition of additional data is rendered difficult or impossible, because 90 per cent of our area has been cleared. The original distribution of any species in Indiana can now be approximated only. The composition of our flora a few centuries hence can only be conjectured. No doubt several of our native species have already disappeared, and many more are doomed to extinction, because destructive agencies such as the cow and hog, axe and plow, and the steam dredge are ever busy. . . . Already the opportunity for obtaining data on the plant life of our prairie has gone. The opportunity for making a record of the original plant life of the barrens of Indiana has forever passed. The opportunity for acquiring a complete knowledge of the dune and lake flora is rapidly disappearing. When we motor over our improved highways among the fields of our alluvial bottoms, if we pause long enough to think, we will realize that the once virgin forest with its numerous native plants has disappeared forever." (Proc. Indiana Acad. Sci., Vol. 34, 1924 P. 39.) And this extract from a letter, dated April 22, 1918, from the late Dr. C. F. Millspaugh, Botanist of the Field Museum of Natural History, will show the need of botanical exploration in this portion of Illinois.

"I hope that you will be able to continue your very interesting and effective collecting and that this Museum may further benefit thereby. The more we work on the Illinois Flora the more we appreciate not only that there is deep need of the result that we hope to attain, but that the state has been all too meagerly worked in its most promising regions."

When Richland County was first settled the forests covered certainly much more than half, possibly as much as two-thirds, of the total area; but they are now reduced to about one-tenth, and of this remnant only 160 acres remain in a condition approaching that of the virgin forest. Such extensive deforestation within so short a time necessarily means the total extirpation of some of the more local trees, shrubs, and other plants; while drainage of swamps or marshy areas, grazing, and forest fires, have also contributed to this loss. The original prairie flora is practically gone, only small remnants remaining here and there, mostly along roadsides and fence-rows, where annual mowing and burning is steadily reducing not only the area and number of such remnants but the number of species composing them. Such places are, in fact, the last refuge of many native plants, both ligneous and herbaceous, chiefly species of the open country and margins or outskirts of the woodlands. One of these, the Chicasaw plum *(Prunus angustifolia)*, plentiful up to ten years ago, is now difficult to find; two of the wild crab-apples *(Malus lancifolia* and *M. platycarpa hoopesi)* have become relatively scarce, and the hawthorns *(Crataegus)*, while still fairly numerous, are widely scattered and far less abundant than they were a decade ago. Even from the woods themselves several species have practically disappeared. The writer has been able to locate, after ten years' search and inquiry, only three linden trees *(Tilia)* one beech tree, and two Kentucky coffee-trees *(Gymnocladus)* in the county.

Fifty years ago the cane *(Arundinaria macrosperma)* formed extensive and in places nearly impenetrable thickets in the bottoms of the Little Wabash and Fox rivers, and before the settlement of the country probably occupied the bottomlands of most of the streams. At the present time, however, every vestige of the cane has disappeared except in two areas of very limited extent. The mistletoe *(Phoradendron flavescens)*, once abundant, is now exceedingly rare, its scarcity being partly due to the disappearance of most of the mature trees of its principal host the common elm *(Ulmus americana)*. The white pond-lily *(Castalia odorata)* was once plentiful in Mutrie Slough and other

similar places, but these have been drained and the aquatic plants have, of course, disappeared.

Recognizing the urgency of prompt action, the writer has, during the past twelve years, devoted as much time as could be spared from other duties to the collecting of specimens of the now existing flora. Unfortunately his opportunities have been relatively few and available at irregular intervals, so that nothing like a systematic exploration has been possible; and consequently it is practically certain, when it is considered that so many species are more or less local, and that not more than 50 of the 670 (approximately) separate areas of woodland in the county have even been set foot in, that a considerable number could be added to this list.

The author's chief interest being in the woody plants, these have naturally received the most attention. Of herbaceous plants, only the grasses and sedges have received anything like special attention; as to the others, the genera *Aster* and *Solidago* are fairly well represented in the author's collection; the aquatic flora has been completely neglected, and it may be said that as to non-ligneous plants in general he has barely "skimmed the surface."

So far as the writer is aware, the only catalogue of the plants of southeastern Illinois north of the Ozark Uplift is Dr. Jacob Schneck's "Catalogue of the Flora of the Wabash Valley below the Mouth of White River", published in 1876 (Cox's Geological Survey of Indiana, volume for 1875, pp. 504-579), in which are listed 867 species of plants. Unfortunately, Dr. Schneck did not, in most cases, specify whether a given species was collected on the Illinois or the Indiana side of the Wabash River; neither did he distinguish between indigenous and naturalized species. From the writer's intimate acquaintance with Dr. Schneck, whom he often accompanied on his collecting trips, he is prepared to state that by far the greater part of the material on which the catalogue was based was collected in Wabash County, Illinois.[1] While very incomplete, from lack of time for thorough investigation of the local flora, Dr. Schneck's catalogue is nevertheless a most interesting and valuable

[1]Dr. Schneck was a physician with a large country practice, and most of his botanizing was done during visits to his patients in the country districts about Mt. Carmel.

contribution, especially from the standpoint of geographic distribution. His list includes twenty-two plants that were, at that time, far out of their known range, most of them being of southern distribution. A posthumous addition to Dr. Schneck's catalogue was published in 1911 (Proceedings of the Indiana Academy Science, 1911, pp. 365-369) by Mr. Chas. C. Deam, State Forester of Indiana, compiled from annotations in Dr. Schneck's handwriting in a copy of the original catalogue. In this paper 150 species are added to the list, making a total of 1017 species; but in this case also there is no indication, except in a few instances, of whether a particular species was found in Illinois or in Indiana.

In 1882 the present writer's "Notes on the Native Trees of the Lower Wabash and White River Valleys, in Illinois and Indiana" was published (Proc. U. S. National Museum, V. pp. 49-88). In this were enumerated, with annotations, 92 species of trees. The following year "Additions and Corrections to the List of Native Trees of the Lower Wabash" appeared (Botanical Gazette, VIII, Dec., 1883, pp. 345-352), and eleven years later, "Additional Notes on the Native Trees of the Lower Wabash Valley" (Proc. U. S. National Museum, XVII, 1894, pp. 409-421, pls. 10-14), both by the same author. All these were based, like Dr. Schneck's catalogue, on observations made on both sides of the Wabash, but chiefly in Wabash County, Illinois, and, like Dr. Schneck's catalogue, these papers were not sufficiently explicit concerning localities where the species mentioned were observed.

No mention seems to have been made of any plants of Richland County until 1921, when a most interesting and instructive paper by Mr. Ernest J. Palmer, entitled "Botanical Reconnaissance of Southern Illinois" appeared (Journ. Arnold Arboretum, 11, Jan., 1921, pp. 129-153). Although Mr. Palmer's paper was based essentially on investigations in the extreme southern counties (Union and Alexander to Gallatin), reference is made, among the 204 species of ligneous plants included in the paper, to 10 species observed in Richland County.[1] The following year

[1]The species mentioned by Mr. Palmer as having been seen by him in Richland County are: *Arundinaria macrosperma, Salix humilis rigidiuscula, Quercus lyrata, XQ. tridentata, Rosa palustris, Acer rubrum drummondi, Cornus stricta, Fraxinus profunda, Catalpa speciosa,* and *Viburnum dentatum.*

11 additional trees were accredited to Richland County in the second edition of Professor Sargent's "Manual of the Trees of North America", these being *Quercus borealis maxima, Q. runcinata, x. Q. exacta, x. Q. saulei,*[2] *Ulmus alta, U. serotina, Malus lancifolia, Crataegus phaenopyrum, Prunus lanata, P. munsoniana,* and *Fraxinus biltmoreana,* these records being based on material sent to Professor Sargent by the writer.

The collections and observations made by the author in various parts of Richland County, mostly since 1914, have, as previously stated, been made at irregular intervals, opportunities for the work being relatively few and brief. Nevertheless the best possible use has been made of the little time that was available, and nearly 2900 numbers, mostly of ligneous plants, have been collected. While extreme points in the county, except the northwest corner, have been visited, it has not been possible to make anything approaching an exploration of the entire area; indeed only about 5½ per cent of the separate wooded areas in the county have been explored. It is, therefore, evident that very much remains to be done before our knowledge of even the ligneous plants of Richland County can be anywhere near complete.

Except in the case of plants that are common and well known, or so distinct as not to require the dictum of experts, all the identifications are by leading botanical authorities. Most of the ligneous plants were determined by Professor C. S. Sargent or, during his illness, by Mr. E. J. Palmer (at the Arnold Arboretum), both of whom have been most kind and obliging. A series of the *Crataegi* (124 numbers) has been examined and, in part named, by Mr. W. W. Eggleston, assistant botanist in the Forest Service and Bureau of Plant Industry, U. S. Department of Agriculture. The grasses were identified by Professor A. S. Hitchcock and Mrs. Agnes Chase; other herbaceous plants mostly by Dr. B. L. Robinson, Dr. Wm. Trelease, Dr. J. N. Greenman, and the late Dr. C. F. Millspaugh; while a considerable collection, made several years prior to 1914 and deposited in the National Herbarium, was

[2]This, however, is an error, since *Q. montana*, one of the parent species, *XQ. saulei* being a hybrid of that species and *Q. alba*, does not occur in Richland County, the nearest point where it is known to grow indigenously being in Martin County, Indiana, about 60 miles farther east.

named by Mr. Paul C. Standley and Mr. E. S. Steele. Mr. B. F. Bush, of Courtney, Missouri, has rendered valuable help in determining certain forms of *Celtis, Fraxinus, Hypericum, Rosa, Tilia, Ulmus* and *Viburnum.*

A considerable part of the material sent, several years ago, to specialists for identification has not yet been reported on; consequently many species of herbaceous plants that might have been included in a catalogue of the Richland County flora must be omitted. This difficulty in obtaining authoritative identification of specimens has been a serious obstacle, wholly unforeseen and unexpected, and is much to be regretted.

The greater part of the material collected by the author in Richland County is deposited in the National Herbarium, the Gray Herbarium, and the herbaria of the Arnold Arboretum, the University of Illinois, the Field Museum of Natural History, and the Missouri Botanical Garden. The author has retained a set of the ligneous plants (except of the earlier collections) for reference.

As a result of the author's studies of the trees and shrubs of Richland County one fact stands out with great clearness; namely, that certain genera are, so far as their component forms are concerned, so little understood as to be in a condition little short of chaos, attempts to identify the species by any of the standard text-books being useless, because their satisfactory determination thereby is in many cases simply impossible. Such genera as *Cornus, Crataegus, Malus, Rosa, Rubus, Salix, Smilax,* and *Vitis* have certainly not been satisfactorily worked out; and the same, although perhaps to a less degree, may be said of *Carya, Amelanchier, Acer, Fraxinus, Tilia, Ulmus,* and *Viburnum.* Of these genera certain species, of course, are so well characterized that no difficulty is found in their identification; but others do not (at least so far as this region is concerned) conform to any of the species as described by standard authorities, or else agree equally well with more than one. The difficulty encountered by the writer in such cases he might himself attribute to his own inexperience or incompetence were it not for the fact that in forms of nearly all the genera named above he has received from leading botanists (sometimes from the same one), on different

occasions, two or even three, determinations for the same thing, based sometimes on specimens from the same individual tree or shrub.[1]

Only a brief statement can be given here as to the composition of the Richland County flora, as far as it is known. Of the total of 907 species and varieties that have been thus far identified, 216 are woody plants, the families most numerously represented being as follows:

Malaceae	42
Fagaceae	18
Salicaceae	16
Juglandaceae	15
Rosaceae	14
Aceraceae	12
Caprifoliaceae	10

The genera with the greatest number of species and varieties are:

Crataegus	31[2]
Quercus	17
Salix	14
Carya	13
Acer	11
Malus	8

In order to determine the life-zone relationships, or position, of Richland County, and especially to ascertain the extent to which its vegetation may be affected by the "climatic handicap" (as compared with an area of cor-

[1]Since the above was written the author has read an excellent paper by a well-known botanist from which the following is quoted. "Every complex genus in our Flora needs further elaboration. Among such may be mentioned Aster, Carex, Cyperus, Meibomia, Panicum, Quercus, Rosa, Rubus, and Viola. In fact there is scarcely a genus but which on critical examination presents surprises. Species have been misunderstood; strange species from the outside are found in our midst; even distinct undescribed species are not rarely brought to view." (Taxonomic Botany and the Washington Botanist. By A. S. Hitchcock, Bureau of Plant Industry; Journal of the National Academy of Sciences, Vol. VII, No. 9, pp. 251-263.)

[2]Many of the Crataegi are species previously known only from Southern Missouri." Two are new species, thus far known only from Richland County, having been described in 1925 (Journ. Arnold Aborstrun, Vol. VI, pp. 2, 3) by Professor Sargent. Some of the species included in the above enumeration have, however, been identified doubtfully or tentatively; but there are a considerable number of others, not included in the count, which have not yet been determined.

The forms of *Malus* include only one of doubtful identification. Among the others there are two of special interest, namely, *M. augustifolia*, a southern species heretofore recognized only in two of the extreme southern counties of Illinois (Pope and Johnson), and *M. platycarpa hooperi*, a very distinct species, previously known only from cultivated trees. Both are not uncommon in Richland County.

The wild crab-apples and hawthorns are not only exceedingly difficult trees to understand, botanically, but, as "weed trees," are becoming scarcer each year. Therefore, in order to preserve as many of the forms of these two genera as practicable of the species indigenous to the county, and segregate them where they can be conveniently studied and compared, the author has been collecting them from "the wild" and transplanting them to Bird Haven, where there are now growing 119 specimens of *Crataegus* and 66 of *Malus*, besides 21 of the former and 8 of the latter that were already growing there when the land was purchased.

responding latitude near the Atlantic Coast), which is said to characterize the Middle West in general, it has, of course, been necessary to compare meteorological records for the two sections. This has been done by selecting nine Weather Bureau Stations in the Lower Wabash Basin and an equal number in the Middle Potomac Basin. The records for the former cover periods averaging 21.8 (19 to 38) years for temperature, and 28.1 (19 to 38) years for precipitation, those for the latter averaging 24.9 (13 to 46) years for temperature and 27.7 (13 to 48) years for precipitation,[1] the average elevation above sea-level of the former being 460.1 (384 to 500) feet, of the latter 237 (50 to 500) feet; all but three stations (one Wabash and two Potomac) being between the parallels of 38° and 39°, and these exceptions barely outside those limits.

Careful comparison of these records shows that the climatic difference between these two regions is in reality not greater than that between almost any two stations in either region, and that, so far as the Lower Wabash Valley is concerned, the alleged "climatic handicap" is rather insignificant and practically negligible as a factor affecting plant life.

The comparison shows that the Lower Wabash Basin has an excess of heat for the six warmer months amounting to 12° (by monthly averages) and for the six colder months a deficiency of 4.8°; that the mean maximum temperature averages higher for every month but three (December, January, and February), the deficiency for these amounting to 3.5°; that the mean minimum temperature also averages higher for every month but two (January and February), the deficiency for which is only 1.5°; and that while the highest recorded temperature is 4° higher (113° against 109°) the lowest recorded temperature is actually 1° *less* (—25° against —26°). As to seasonal averages, the Lower Wabash Basin shows an excess of heat amounting to 1.8° for Spring, 1.7° for Summer, and 1.4° for Autumn; and a deficiency of only 0.8° for Winter. The average date of the first Killing frost (or temperature of 32°) is exactly the same for the two regions (October 20); while that of

[1]For precipitation the average of 12 stations in the Lower Wabash Basin has been computed but only 9 for the Middle Potomac Basin, the records for one of the latter covering too short a period (6 years only).

the last Killing frost in Spring is three days earlier in the Lower Wabash Basin (April 15 against April 18).

As to precipitation, the Lower Wabash region shows an excess for each month except July and August, the total excess (by monthly averages being 3.34 inches, the deficiency for July being 0.30 and that for August 0.21 of an inch; the total amount for the year averaging 41.89 inches against 38.85 inches for the Middle Potomac region.

While collections of the local flora are far from being complete they have covered the ground sufficiently to indicate pretty clearly the position of Richland County in relation to life-zone areas. The following enumeration does not include several forms which at present are of doubtful status on account of insufficient material; should these prove to have been correctly identified (for example *Ulmus serotina*) they would increase considerably the number of species of southern range.

By species of northern, southern, or eastern range is meant those whose mass distribution is distinctly in the direction of those points of the compass. Those considered of central range are mainly if not strictly limited, as indigenous plants, to the Mississippi Valley, as a whole or in part, though a considerable number of these extend so far southward as to reach the Gulf States or, in some instances, even Florida, and therefore might almost as well be included with those of southern range; indeed, in some instances it is hard to decide as to the category in which a species should be placed.

Ligneous Plants of Richland County.

Species of northern range	13
Species of southern range	38
Species of central range	56
Species of eastern range	1
Species of general range	108
Total number	216

The herbaceous flora of Richland County is, as already stated, very imperfectly known, nevertheless, so far as the

species have been determined they show approximately the same relative proportions as the ligneous plants.

Herbaceous Plants of Richland County.

Species of northern range	59
Species of southern range	73
Species of central range	66
Species of eastern range	7
Species of general range	(486)[1]
Total number	691

[1]This number, however, includes many naturalized species, the elimination of which is prevented by lack of time.

A statement of the number of identified herbaceous species and varieties in each family that have been collected to date in Richland County may be of interest. They are here given in numerical order:

Compositae	100	Cichoriaceae	16
Poaceae	83	Violaceae	13
Cyperaceae	60	Asclepiadaceae	13
Fabaceae	30	Ammiaceae	12
Labiatae	22	Polypodiaceae	11
Scrophulariaceae	22	Cruciferae	11
Polygonaceae	21	Solanaceae	11
Ranunculaceae	17		

(All the other families are represented by less than 10 each. This enumeration also includes naturalized as well as indigenous species.)

The genera represented by 10 or more species are the following:

Carex	46	Viola	13
Aster	18	Panicum	12
Solidago	14	Asclepias	10

MODIFICATIONS AND ASSOCIATED STRUCTURES OF THE FIRST THREE VERTEBRAE IN THE BUFFALO FISH ICTIOBUS URUS.*

L. A. ADAMS.

There is a very striking modification of the first three vertebrae in the Cyprinodont fishes, correlated with the swim-bladder and also with the Weberian ossicles, a small chain of bones connected with a hydrostatic function. The modification consists of a great enlargement of the parts of the vertebrae to form a large neural spine region, the Weberian ossicles, a very large and specialized haemal rib structure which supplies a support for the ossicles, cavities for the blood vessels and an anterior base for the swim-bladder. These parts of the vertebrae have been so modified that it has been necessary to study their embryological development to determine their exact homologies, and in some cases, there is still doubt as to their exact origin. This modification of the vertebrae and the development of the ossicles is characteristic of the Cyprinodont fishes, occuring in no other group. Hydrostatic organs exist in other fishes, but they function in a different way and without the aid of special skeletal changes.

The first vertebra is not greatly modified except in the antero-posterior compression of the centrum, which makes this part thin and disc like. A long, thin process extends out from the centrum, paralleling and closely appressed to a similar structure from the second vertebra. The dorsal fact of the centrum is marked by two deep pits that serve as articulations for the ventrally projecting processes of scaphium, the second Weberian ossicle. (Figs. 1, 3 and 4.)

The first vertebra has neural arches but no development of a neural spine. The claustrum, the first Weberian ossicle, is articulated with the antero-ventral face of the neural arch, while the antero-dorsal face articulates with the skull.

The second vertebra is much more modified than the first, with a large neural spine, a strong lateral process and

*Contributions from the Zoological Laboratory of the University of Illinois, No. 313.

highly specialized haemal process and spine. The neural arch projects anteriorly and supports the neural arch of the first, while the neural spine is much enlarged, heavy and broad at the base with a greatly expanded neural spine that is as long as the centra of the three vertebrae. The principal function of this spine is in supplying surface for the muscles. The haemal process is broad and long with a strong attachment to the centrum. This process joins a similar process from the third vertebra to form the expanded haemal structure. A transverse process extends out laterally, paralleling a similar process from the first vertebra. The neural arch supplies the principal articulation for the neural arch of the first vertebra and at its anterior region, supplies an articulation for the third Weberian ossicle, the intercalarium. (See Figs. 3 and 4.) The lateral surface of the centra of both the second and the third vertebra, serve as an articulation for tripus, the fourth ossicle which works on these centra, using them as a fulcrum.

The third vertebra is marked by a long spine from the neural arch, which is pushed posteriorly by the spine of the second. The neural arch is wide but the spine is thin, narrow and closely joined to the posterior face of the second. The haemal process joins with the same structure of the second vertebra as before mentioned, thus forming a large ventral bone with expanded sides. (Figs. 4 and 5.) A pair of small processes are directed posteriorly to aid in the association of the Weberian ossicles with the swim bladder and to form a passage for the blood vessels. This process extends to the posterior end of the fifth vertebra. Laterally the haemal processes of the second and third vertebrae fuse and form a ventrally projecting, triangular structure with a V shaped trough which extends to the ventral end of the bone. The dorsal end is forked in its origin from the two centra. The anterior face is large, irregular and deeply concave. The pharyngeal structures extend into this concavity, while the lateral wing is attached to the posterior face of the cleithrum by muscle. Just ventral to the centra there is a large haemal passage.

The posterior face is much more irregular than the anterior and more varied in its architecture. (Fig. 5). The haemal process extends laterally from the third vertebra,

joining a corresponding process of the second. From the latero-ventral region of the third, a part of the haemal process extends ventrally, to form a process that extends along the ventral side of the centra, while a small wing extends ventrally to join the extension of the haemal structure. Two large, lateral fenestra supply openings, through which the most posterior of the Weberian ossicles extend, to come in contact with the swim bladder, while on the median line there is a bony covered passage way for the return of the veins from the head region. (See Fig. 5). Posterior to the three modified vertebrae, the rest assume normal shape and conditions.

Weberian Ossicles.

The Weberian ossicles consist of a small chain of three or four bones that in all Cyprinodonts, lie along the centra of the first three vertebrae. They were first seen by Rosenthal, but they were first described by E. H. Weber in 1820, in a now famous paper entitled "De aure et auditu hominis et animalium." Weber considered the bones homologous with those of the mammalian ear and used the same names in their description, but later study showed that they were different structures and not homologous, so different names were supplied for them. It was shown that the chain is connected with the semicircular canals of the ear and it is now assumed that they have a part in a hydrostatic function, by which the fish is informed of changes in pressure in the swim-bladder. Thilo calls the apparatus a manometer and thinks that the pressure is applied through the bones to the fluids of the brain and spinal cord, where the sensation is registered. It is difficult to see just how this would work and also to determine what special receiving organs would get the sensation through this channel. The Weberian ossicles usually consist of a chain of three or four small bones, the claustrum the most anterior, then follow the scaphium, intercalarium and the tripus. (See Fig. 3.)

The most anterior of the chain, the claustrum, is attached to the neural arch of the first vertebra, facing ventrally and slightly to the posterior. It is firmly sutured to the neural arch so that there is no possible movement, although the suture lines are retained even in very old speci-

mens. The bone is cupped, with expanded lips that meet a similar face on the scaphium. The lips of the two bones meet in a close articulation except for a small opening on the inner side which may be correlated with the hydrostatic function. The origin is not settled, but it is generally considered as having its origin from the skull vertebra according to Goodrich and Nusbaum. Wright considers it as a modification of the spine of the first vertebra. (Fig 2.)*

Scaphium, the second bone of the series, articulates with the claustrum. It also is cup shaped with expanded lips so that it can be closely appressed to the claustrum, or drawn away as the pressure on the swim bladder increases. It has a peg like process on the ventral side which fits, into a corresponding depression on the dorsal side of the centrum of the first vertebra. (Fig. 2.)

When there is a movement of the ossicles, it is on this bearing that the scaphium moves. A ligament attaches it to the intercalarium and finally to tripus.

The third bone of the series, the intercalarium, is a small splint of bone that extends from the ligament that joins the scaphium and tripus, to the anterior part of the centrum of the second vertebra. It serves as a brace for the chain of bones in the ossicle series and holds the bones out from the neural processes. Its origin is the first neural arch according to Goodrich, but others derive it from the neural arch of the second vertebra. It is the incus of Weber. (See Figs. 3 and 4.)

The fourth and the most conspicuous of the ossicles is tripus, which connects the ossicles directly with the swim-bladder. It is a flat, blade like bone, narrowed at the ends, with the anterior end in contact with the other members of the series, through a connective tissue band, while the posterior end is connected with the swim bladder. On the inner or mesial face there is a large bearing at right angles to the main bone, that serves as the bearing for the articulation with the centra of the second and third vertebrae. Extending posteriorly, it passes under the haemal arches of the third vertebra, and comes in contact with the anterior end of the swim bladder. (Figs. 3 and 4.) The bone is nicely balanced on its bearing so that a very free movement is possible, and a slight change in the density of the gas in the swim-bladder will cause a movement of tripus and through

it, a movement of the whole series. The origin is given by Goodrich as a modification of the first rib, while Sagemehl gives it as a modification of the third rib.

Mechanically, the Weberian ossicles are beautifully adapted for the purpose that seems to be theirs, of giving the animal notice of changes in depth and consequently of changes in pressure. Correlated with these structures, in the adaptation are the first three vertebrae, which aid in the mechanism by first supplying the material from which the ossicles are made and secondly by developing speciliazations of their parts that will assist the ossicles in performing their function. In no other group is the modification of the vertebrae so striking as in the genus Ictiobus.

While these structures have been studied for years it is quite evident that much remains to be done on them, before they are thoroughly understood. Both developmental and experimental studies should be used to add to our knowledge of the origin of the parts and to clear our ideas of the function of the whole apparatus.

Bibliography (partial).

Goodrich, E. S. 1909. Treatise on Zoology, Cyclostomes and Fishes. Vol. IX.

Nusbaum, J. 1908. Entwickelungsgeschichte und morphologische Beurteilung der Occipitalregion des Schädels und der Weberschen Knochenchen bei den Knochenfischen. Anat. Anz. Vol. 32, pp. 513-532.

Sagemehl M. 1891. Beiträge zur vergleichenden Anatomie der Fische. IV Das Cranium der Cyprinoiden. Morph. Jahrb. Vol. 17, pp. 489-595.

Legend.

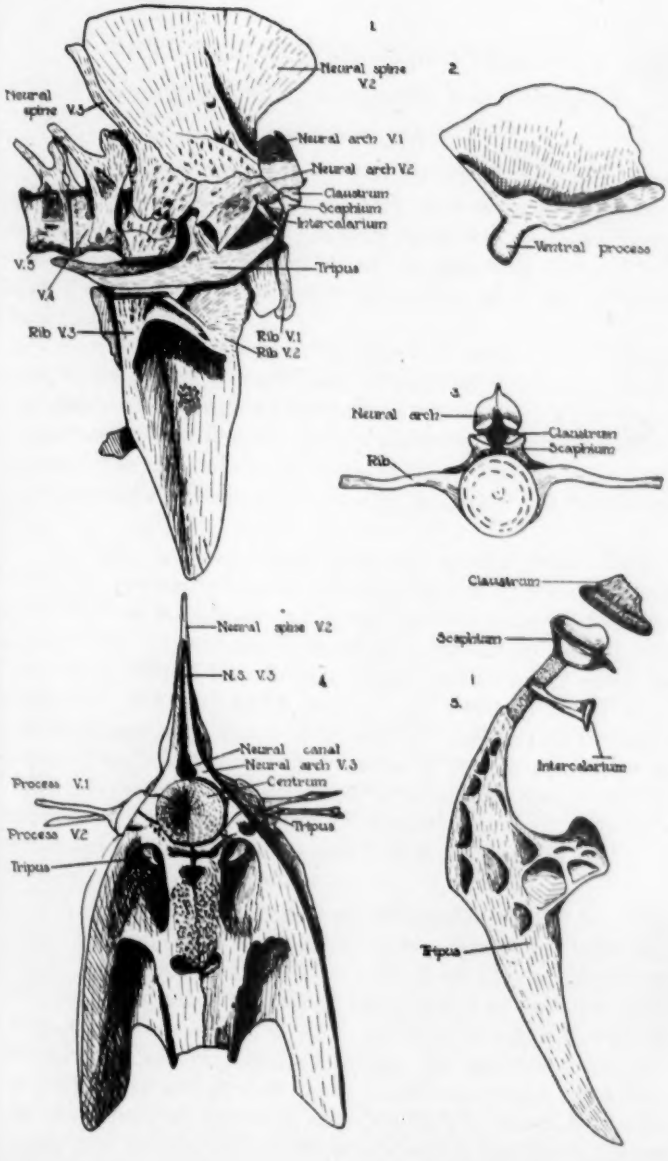
Fig. 1 Lateral view of the first three vertebrae showing the ossicles. A part of the haemal arch is removed. X⅔.

Fig. 2 Dorsal view of the right scaphium. X5.

Fig. 3 Anterior view of the first vertebra showing the position of the claustrum and scaphium. X⅔.

Fig. 4 Posterior view of the third vertebra, showing the relation of the structures in this aspect. X⅔.

Fig. 5 Lateral view of the Weberian ossicles, showing the bones in position. Left side. X5.


1
Neural spine V.2
Neural spine V.3
Neural arch V.1
Neural arch V.2
Claustrum
Scaphium
Intercalarium
V.5
V.4
Tripus
Rib V.3
Rib V.1
Rib V.2
2
Ventral process
3
Neural arch
Claustrum
Scaphium
Rib
4
Neural spine V.2
N.S. V.3
Neural canal
Neural arch V.3
Centrum
Process V.1
Process V.2
Tripus
Tripus
Claustrum
Scaphium
1
5
Intercalarium
Tripus

WHAT HIGH SCHOOL STUDENTS EAT.

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Why are we "too fat" or "too skinny"? This is a vital question for many high school girls, and some boys, to say nothing of older maidens, middle aged matrons and some gentlemen, of either the rotund or the bean pole type. What does the quantity of food eaten have to do with this momentous question?

Not in the hope of adding much, if any, new information to what has already been scientifically demonstrated, but more with a view to learning whether the girl, already underweight and anemic, who is starving herself even now against the day when she *may* be too stout, is or is not striving against fate, we undertook to gather the following data.

A class of one hundred-twenty second year biology students averaging nearly sixteen years in age were asked on a certain Wednesday to record as they came to the laboratory the various portions of food consumed during the preceding twenty-four hours. Kinds and amounts eaten at breakfast, the noon lunch, supper, and between meals were listed separately. There were sixty-five girls and fifty-five boys. They came from the homes of merchants, miners, railroad workers, farmers and professional people. They represented the average family of a prosperous community. Wednesday was chosen to avoid irregularities in diet due to week end social activities.

A high class cafeteria is maintained in the school. The majority get their noon meal there. Some go home for lunch and others bring all or part from home. Of course the food was not weighed but each item was carefully estimated as to amount, and its food value in calories was estimated by use of standard tables, the calories from fat, carbohydrate and protein being listed separately. The data do not represent precisely any one child's actual food consumption, but we believe the errors above and below normal in both the amount consumed daily and in estimation of

calories are such that we get an average that has value. In most cases the students said that the record represented fairly well their average daily consumption.

It is apparent, from questions put to this class, from studies made with other classes, from observations made in the cafeteria where three or four hundred students eat daily and from the observations of restaurant and hotel people, that most individuals and most families fall into a routine as regards the kind and quantity of food used. When you know the person or the family you can guess with reasonable accuracy what will be ordered and eaten at the next meal. So intent are students on getting the thing to which they are accustomed that they pass by without notice some foods which are served frequently such as loganberries or figs in sirup. Some students were unaware that such foods had been before their eyes at meal time. So we think and many of the students said that this snap shot at their daily food habits is a fairly good likeness.

In this connection other facts appeared. A surprising number of students had never tasted foods which are more or less commonly used in other families, such as mackerel, codfish, asparagus, rhubarb, okra, turnips, dried beef, veal, currant jelly, gooseberry pie and even the meat of turkey. Strange to say, many expressed a positive (imaginary of course) dislike for foods which they admitted they had never tasted. These and other illustrations too numerous to state here point to the fact that the average American when he is at his regular eating place uses food that varies little more than the rations of an army or the menus of charitable or penal institutions. The good wife may plan and stew both literally and figuratively to get up something new but the fact remains that she and her family after all stick to much the same substantial fare.

Our record of the sixty-five girls and fifty-five boys shows that eight girls and none of the boys omitted breakfast. Seven girls and one boy did without lunch at noon. Two boys and three girls went without supper. Forty-two boys and sixty-two girls ate between meals. Some of the reasons for omitting meals were trivial. Some likes and dislikes for certain foods grew from chance impulses. Insistence on the part of parents that certain foods should be eaten grew

into positive dislikes on the part of the child. One boy always drinks much water with his meals at home but takes no water with his lunch at school. His mother keeps his glass full at home, but he must stop at the cafeteria fountain to fill his glass at school so he goes without. Those in charge of the young in the development of their food habits might profit by more scientific inquiry into why we eat what we do eat. What a multitude of parents would rise up to call him blessed who could point the way to prevent children from being "finicky" about their eating!

Our grand totals for the one hundred twenty young people show 67,649 calories supplied by the breakfasts, 70,796 at noon and 91,291 at the evening meal. To this we add 38,449 calories from the candy, cake, fruit, bread, meat, etc. eaten between meals, making a total of 268,352 calories for the day. Thus more than 14% of the food was taken between meals.

The averages per child are more interesting. They are, estimated in calories; for breakfast 564; for lunch 590; for supper 761; between meals 320; total 2,235 calories per day for each child. The average for boys is 2,612 and for girls 1,918.

Nine boys and eleven girls were more than five pounds overweight, and twenty-one boys and thirty-one girls were more than five pounds underweight. Getting down to the school girl's problem of what makes one "too fat" or "too skinny", we find that, of the nine boys who were overweight, five ate more than the average boy and four ate less. Of the eleven girls who were overweight, three ate more than the average and eight less. The evidence is slightly in favor of eating *more* if you would be slender.

Now, considering the fifty-two who were underweight, nine boys ate more than the average and twelve ate less. Fifteen girls who were underweight ate more than the average and sixteen ate less. Here the evidence is slightly in favor of eating *less* if you would be slender.

Considering extreme cases, four girls who were credited with more calories between meals than at any regular meal were little, if any, either overweight or underweight. This interferes with our theories concerning the importance of eating only at regular meal times, but the sting is less

penetrating when we remember that these girls rather regularly eat much at certain times between meals. The girl charged up with more calories per day than any other girl, a total of 3,383, is very active, weighs ninety pounds and is nineteen pounds underweight. Another girl whose record is but 958 calories per day is twenty-eight pounds overweight. Still another who eats two meals a day and nothing between meals used but 1,042 calories and is 52 pounds overweight. A boy charged with 4,155 calories, more than any other boy, is but seven pounds overweight.

So far as our limited data indicate, the amount eaten has very little to do with whether one is stout or slender. Other influences such as heredity, sleep, exercise, regularity of habits and the variety and kinds of food used seem to have far more to do with the problem. However, careful note of the nutritive ratio was made with each individual, and there was little to indicate that even the kind of food had much to do with the weight. Just as often as otherwise, the child whose protein ratio was high was of good weight, and the eaters of starch and sugar were about as often as not thin. So most of us have decided to forget whether we are to be fat or skinny and to eat as much as we crave of those things which do not interfere with our comfort or health while we go about attending to those habits which we believe have more to do with our well being and comfort.

MARINE AQUARIA FOR HIGH SCHOOLS AND COLLEGES.

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Living marine animals and plants for class use in biological laboratories far removed from the ocean are generally not even considered possible. Students in such laboratories see only preserved specimens or pictures. The University of Illinois zoological laboratory has had living marine animals shipped in from Woods Hole, Mass., for a number of years during the mid winter season. The animals generally lasted but a few days and were soon forgotten. The past four years an attempt has been made to keep these animals alive throughout the year and longer with marked success.

Sea water was shipped in barrels at a cost of about $8.00 per barrel but this was found to be too expensive and results obtained were not as good as synthetic water made according to Ditmar's formula which cost about $1.00 per barrel. Sea water made according to this formula can be made from either tap water or rain water. C. P. dry chemicals were used. The formula is as follows:

Sodium chloride	27.213 gm. per L.
Magnesium chloride	3.807 gm. per L.
Magnesium sulphate	1.658 gm. per L.
Calcium sulphate	1.260 gm. per L.
Potassium sulphate	0.863 gm. per L.
Magnesium bromide	0.076 gm. per L.
Calcium carbonate	0.123 gm. per L.

In making up sea water from tap water the amount of $CaCo_3$ contained should be known. In most cases this may be omitted from the formula. The tap water at the University of Illinois contained 10.22 gms. per gallon. This amount together with other impurities may be reduced by bringing the water to the boiling point and then allowing it to stand and cool. Excess carbonates settle to the bottom of the container and the supernatant fluid is siphoned off. The C. P. dry chemicals are added according to the proportions given in the formula and are allowed to dissolve. This water may be made up a year or more in advance if stored in tightly

corked carboys, however it is best to start the aquaria some time in advance of the arrival of the animals.

Since the publication of a paper by Thomas (1925), considerable advance has been made in the handling of the animals upon their arrival. Shipments have been made from the Pacific as well as from the Atlantic. Animals sent from the Marine Biological Laboratories at Woods Hole, Mass., come in paraffin lined wooden buckets and may be shipped by express without danger of spoiling from November to March to any point in the Central States, although shipments have come through as late as June in good condition. If the aquaria are started with a shipment of Ulva or sea lettuce, Fucus, and eel grass several months before the animals are ordered they will be in better condition to receive animals.

Small aquaria 9″ x 9″ x 14″ with aluminum frames and slate bottoms have proved very satisfactory, although larger aquaria 29″ x 20″ x 18″ with alberine stone ends and bottoms have been better. The small aquaria have loose fitting covers to aid in cutting down evaporation. The use of covers on the large aquaria proved very unsatisfactory as the rise in temperature due to the covers was more detrimental than the cutting down of the evaporation. Loss from evaporation is made by the addition of rain water, sprinkling it on slowly to avoid a sudden change in concentration. When the synthetic sea water is first placed in the aquarium, about three-fourths full, a line is drawn to mark the water level. If rain water is added every few days so as to keep the water level fairly constant better results are obtained.

A layer of coarse wood charcoal covered with gravel and fine white filter sand helps to keep down gases formed from decomposition of organic materials and also gives a place of lodgment for burrowing forms. Bits of brick and shells scattered about on top serve as a place for attachment of plants and sessile animals.

The addition of one or two clams to each aquarium helps to purify the water. Red, brown, and green algae do well, especially Ulva. Practically all tide-pool life has been kept for a year or more, some forms for over two years. The heat of the summer months in the green house at the Vivarium where some aquaria are kept takes a considerable

toll of life, but aquaria in the laboratory in windows on the north at a cooler temperature go through without much loss. A ten dollar order should be sufficient to supply a dozen aquaria. A twenty-five dollar order might give a greater variety but would necessitate a considerable waste unless spread out over two dozen or more aquaria.

The greatest temptation is to crowd too many animals into one aquarium. A typical grouping of animals might be cited taking examples from among fourteen in the vivarium. Aquarium No. 1, size 29″ x 20″ x 18″, has one star fish, two small sea-urchins, one sea cucumber, a sponge, a few serpulids or tube worms, a clam, a few Bryozoa, and corals, four mud snails and numerous small micro crustacea. The sea urchins have developed from larval forms brought in on the introduced Ulva. The sea cucumber has lived for over a year and has regenerated its entire internal organization. The beginner may want to throw out sea cucumbers that have cast their digestive apparatus due to excessive handling, however, if the viscera spewed into the aquaria are removed and the animal is not disturbed regeneration generally takes place. The star fish placed in the aquarium last fall has regenerated two new arms. No. 4 aquarium contains a sea urchin which has developed from the larval state, a sea anemone which has produced numerous small anemones by budding, corals which have spread and developed new colonies, tube worms which have laid their eggs and numerous young have developed and have become attached to the vegetation and to the sides of the aquarium, and Clava leptostyla another colonial coelenterate. No. 10 contains four fiddler crabs which have been living for over a year and six Limulus or horse shoe crabs. This aquarium is divided so that half of it is a miniature beach of fine white filter sand where the fiddler crabs tunnel and the horseshoe crabs bury themselves. Crabs should not be placed with other animals. Different species of crabs with large pincher feet should not be placed together. A shore crab was removed because of its canabalistic habits to another aquarium where on April 10 it was found laying eggs. Aquarium No. 2 contains barnacles, sea anemones, two clams, snails, serpulids and Nereis which have reproduced, and Syncoryne mirabilis, a colonial coelenterate which has spread over the glass of the aquarium. Two years ago Obelia commissura-

lis McCr. produced medusa or jelly fish which were observed by an entire class of over two hundred students. Recently Tunicates have developed and their colonies have spread about the aquarium. They make splendid demonstration specimens to show the reversal of the blood flow and represent the primitive tho degenerate Chordate.

In the balanced aquarium the feeding of the animals is not a problem. The production of micro crustacea is great enough to furnish the coelenterates with food. Crabs and star fish may be fed crushed snails sparingly once a month or the crabs and sea anemones may be given bits of raw beef or codfish on a stick. The codfish is prepared from a good commercial brand of the dried product by soaking it in running tap water for a half day. The sea water in which the animals are shipped should not be used for some time and then only after thorough aeration. However, the plankton which it contains should be strained off through a silk handkerchief or bolting cloth for sometimes it contains larval forms which may develop later to create new surprises.

The success of marine aquaria depends upon the prompt removal of dead animals, excess food, decayed vegetation, and white molds that may appear. Some aeration in addition to oxygen from growing plants is advisable. The appearance of turbid water or a foamy froth indicates animals are dying and should be removed. And last the interest and attention of the one in charge is necessary. For those who are interested in making biology a live subject marine aquaria are practical aids to this end.

REFERENCES:

1925 Thomas, Lyell J. Living Marine Animal for Our Inland Laboratories. Trans. Amer. Micros. Soc. 44:38-41.

THE COATI.

H. V. GIVENS, JOILET TOWNSHIP HIGH SCHOOL, JOLIET, ILL.

During September, 1925, a lone specimen of Coati mundis (Nasua narica) was killed near Lockport, Illinois. This mammal was discovered in a tree by a farmer named George Bump.

This Coati is a native of South America and Mexico, sometimes traveling across the border into southern United States. In South America they range as far south as Paraguay. They hunt in bands, several families running together. They live in trees and on the ground. They live on small animals, fruit and roots. The latter they obtain by digging with their badger-like feet or with their hog-like snout.

The Mexicans call them Tejons or raccoons. Since they are active and playful, they are often used as pets. Maybe that will explain the appearance of this lone specimen so far from its native habitat.

THE FAIRY SHRIMPS OF ILLINOIS[1]

H. J. VAN CLEAVE.

The fairy shrimps of Illinois have been but little studied. Prof. S. A. Forbes, in the early days, directed considerable attention to this group and brought together a very representative collection of specimens. In more recent years they have been neglected. Recently, I have had the opportunity of examining collections from various parts of the country and as a result have accumulated some records of the occurrence of two species formerly not recorded from Illinois. One of these includes the record of a genus not previously listed for the State.

In 1876, Prof. Forbes described *Eubranchipus serratus* from specimens collected at Normal, Illinois, in April, 1876. The type material of this species remained in the collections of the Illinois State Laboratory of Natural History. I have had the privilege of examining these collections of Eubranchipus. The original alcoholic material upon which the description of *E. serratus* is based had been dried up. Some years ago Prof. Frank Smith in reexamining these specimens succeeded in restoring them to the extent that many of the diagnostic characters were observable. In addition to this type material, the Natural History Survey collections contain series of *Eubranchipus serratus* collected by Forbes from the type locality at Normal, Illinois, covering the period from 1876 to 1882. The restored type specimens and others in the collection identified by Forbes agree in all details with specimens occurring commonly in the vicinity of Urbana, Illinois.

A. S. Pearse, in 1912, described what he deemed to be a new species of Eubranchipus under the name of *Eubranchipus dadayi*. His description and his figures differ in no manner from specimens of *E. serratus* from the type locality identified by Forbes. I therefore maintain that *Eubranchipus dadayi* Pearse, 1912 is a direct synonym of *Eubranchipus serratus* Forbes, 1876.

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[1]Contributions from the Zoological Laboratory of the University of Illinois, No. 311.

In preparing the key to the Phyllopoda for Ward and Whipple's Fresh-Water Biology, Pearse (1918) made use of characters noted by Forbes in the original description of *E. serratus* to run this species to an entirely different section of the key from that including his species *E. dadayi*. The identity of the two species was thereby obscured.

Forbes (1876:13) characterized the abdominal segments as "narrow in front, with rounded anterior angles, while the posterior angles are produced backward, giving a decidedly serrate appearance to the abdominal margin." Later (Page 22) he laid less stress upon the angular projections of the abdomen and described the abdomen as "somewhat serrate." In fact such is the condition shown in his drawing of the abdomen (Fig. 21 Plate 5).

Pearse (1918: 669) construed this serrate appearance of the abdominal segments as due to lateral projections similar to those described for Hay's species *E. gelidus*. By so doing, Pearse grouped *E. serratus* with *E. gelidus* and failed to recognize the identity between *E. serratus* and *E. dadayi*.

Only after collecting Eubranchipus locally over a period of years and after a careful examination of the Forbes collections did the writer become convinced of the invalidity of *E. dadayi* which must fall as a synonym to *E. serratus*.

Thru the courtesy of Prof. L. M. Turner of Blackburn College at Carlinville, Illinois, I recently received specimens of Eubranchipus collected from temporary pools in February, 1927. These individuals very clearly belong to the species *Eubranchipus vernalis*, one of the species characteristic of the eastern states, but previously not recorded from Illinois. Smaller individuals of this same species are in my collection from another locality in southern Illinois. These last mentioned specimens were collected by Mr. W. F. Shay near Mulberry Grove in the very early part of January, 1926.

Unidentified fairy shrimps from East St. Louis, Illinois, July 18, 1906, in the collection of the Illinois Natural History Survey have been identified as *Streptocephalus coloradensis* Dodds. This species, described by Dodds, from mountain lakes of 5,000 to 8,500 feet elevation in Colorado,

has not been reported from Illinois previously. In fact the present record is the first published account of the occurrence of this genus within the State.

In connection with the study of material incident to the preparation of this paper microscopic mounts were prepared to show the heads of four species of Eubranchipus in similar orientation. These mounts were photographed to the same scale of magnification and are here reproduced as figures 1-4.

REFERENCES

Dodds, G. S. 1915. A Key to the Entomostraca of Colorado. Univ. of Colorado Studies, Vol. XI. No. 4:265-298.

Forbes, S. A. 1876. List of Illinois Crustacea with Descriptions of New Species. Bull. Ill. Museum of Natural History, 1:3-25.

Pearse, A. S. 1912. Notes on Phyllopod Crustacea. Michigan Acad. Sci., 14:191-197.

— — 1918. The Fairy Shrimps (Phyllopoda). Ward and Whipple's Freshwater Biology. Wiley and Sons, New York: 661-675.

EXPLANATION OF FIGURES.

Figures 1 to 4. Microphotographs showing the heads of four species of Eubranchipus at same magnification. In each instance the stained head was mounted in damar with its caudal or posterior surface uppermost. The large jaw-like appendages are the second antennae, modified for clasping during copulation. These modifications are lacking in the females.

Fig. 1. *Eubranchipus vernalis*, collected at Carlinville, Illinois.

Fig. 2. *Eubranchipus gelidus*, collected at Syracuse, New York.

Fig. 3. *Eubranchipus serratus*, collected at Urbana, Illinois.

Fig. 4. *Eubranchipus ornatus*, collected at Bloomington, Minnesota. (Ill. State Natural History Collection, No. 31272).

A STUDY OF THE CHARACTERS FOR THE IDENTIFICATION OF THE SNAKES OF ILLINOIS[1].

H. J. VAN CLEAVE

Ignorance and progress are two of the conditions responsible for the sure and rapid extermination of our native snakes. Ignorance of their economic importance and an exaggerated sense of danger have combined to place the harmless snake on the defensive whenever he and man meet. Add to this the fact that modern intensive agriculture and marked increase in population are speedily destroying the native habitats of snakes and you begin to appreciate why snakes are becoming less common throughout our State. It is only thirty-five years since H. Garman (1892) prepared his valuable contribution entitled "A Synopsis of the Reptiles and Amphibians of Illinois," yet in this relatively short interim many of the snakes which he recorded as common throughout the State are but rarely seen today even by those who go into the field for the sole purpose of finding them.

It is rather poor sporting sentiment to kill a snake on sight from fear that it might be one of the relatively rare, dangerous varieties, especially when it is well known that most of the snakes in our vicinity are distinctly beneficial to man. The fact that a few snakes are dangerous seems slight provocation for condemning every creature that crawls. Few people are willing to look closely enough at the snake which they meet to be able to recognize one kind from another. "Garter snake," "rattle snake," and "water moccasin" are about the only names that the average person calls to mind when he attempts to name a snake which he has encountered. As a matter of fact there are forty-one different species and varieties of snakes found within the State of Illinois.

In the belief that ignorance as to the kinds of snakes is largely responsible for the "kill on sight" policy, the following tables have been prepared as an aid to the recognition of the species occurring within this State. Many of the forms here listed are very limited in their distribution.

[1]Contributions from the Zoological Laboratory of the University of Illinois, No. 312.

TABLE I.

ARRANGEMENT OF THE SNAKES OF ILLINOIS ACCORDING TO THE DORSAL COLOR OR COLOR PATTERN.

Solid color only	Longitudinal stripes only	Spots or cross bands only	Spots and longitudinal stripes	Solid color with neck ring only
1.* *Carphophis amoena helenae* 2. *Farancia abacura* 8. *Liopeltis vernalis* 9. *Opheodrys aestivus* 10. *Coluber constrictor constrictor* 11. *Coluber constrictor flaviventris* 13. *Elaphe obsoleta obsoleta* 27. *Natrix sipedon erythrogaster* 30. *Virginia valeriae elegans* 31. *Potamophis striatulus*	22. *Natrix grahamii* 25. *Natrix septemvittata* 28. *Storeria dekayi* 32. *Tropodiclonium lineatum* 34. *Thamnophis sauritus proximus* 35. *Thamnophis sauritus sauritus*	6. *Heterodon contortrix* 7. *Heterodon simus* 10. *Coluber constrictor constrictor* 11. *Coluber constrictor flaviventris* 12. *Elaphe guttata* 13. *Elaphe obsoleta obsoleta* 14. *Elaphe vulpina* 15. *Pituophis sayi* 16. *Lampropeltis calligaster* 17. *Lampropeltis getulus holbrooki* 18. *Lampropeltis getulus nigra* 19. *Lampropeltis triangulum triangulum* 20. *Lampropeltis triangulum syspila* 21. *Natrix cyclopion* 23. *Natrix kirtlandii* 24. *Natrix rhombifera* 26. *Natrix sipedon sipedon* 31. *Virginia valeriae elegans* 38. *Agkistrodon mokasen* 39. *Agkistrodon piscivorus* 40. *Sistrurus catenatus catenatus* 41. *Crotalus horridus*	28. *Storeria dekayi* 29. *Storeria occipitomaculata* 32. *Tropidoclonium lineatum* 33. *Thamnophis radix radix* 36. *Thamnophis sirtalis sirtalis* 37. *Thamnophis sirtalis parietalis*	3. *Diadophis punctatus arnyi* 4. *Diadophis punctatus edwardsii* 5. *Diadophis punctatus strictogenys*

*The numbers preceding species names refer to the numerical arrangement of the species in Table II. By consulting Table II

*The numbers preceding species names refer to the species list (Appendix 1) of the species in Table II. Re-numbering Table II

THIS CHART WILL BE THE FIRST CHART
APPEARING AT THE END OF THIS FILM

Some are included on the basis of a few reports from the southern extremity of the State. Consequently the entire list would not be encountered at any one locality.

The positive identification of many of the snakes rests on characters such as the number of rows of body scales and number and arrangement of the minute scales covering the head (see Table II). However, color pattern is highly distinctive of many forms. As the first step in recognition the color or color pattern furnishes one of the most obvious clues. The Illinois species of snakes show five distinctive types of color marking as indicated in Table I. In this table attention is directed to the color of the dorsal part of the body only.

A key at best gives only part of the information which a student may desire when attempting to identify an unknown specimen. There is always the question of how one species agrees with or differs from another in respect to characters about which the key is silent. Thus an alternative key may separate two species on the presence of some character in one which is lacking in the other but leaves the reader in complete ignorance of how generally the feature in question may be represented in still other species. This condition has come to my attention frequently in connection with the teaching of classes in systematic Zoology. The aid of a number of graduate students was secured in the preparation of a table to present a full comparison of some of the taxonomic characters more commonly utilized in the identification of snakes. While most of the information presented in Table II. is available through the literature, it seemed worth while to put it into tabular form for ease of immediate comparison.

Within recent years the scientific names of snakes have undergone radical changes. As a consequence, many of the prominent early lists and keys have impaired value to the general student. In the accompanying tables the nomenclature is taken from the revised edition of Stejneger and Barbour's Check List, except in a few instances where the nomenclature of Blanchard has been followed.

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*The technical terms employed in Table II. may be defined briefly as follows:

Dorsal scales: the lines of small scales covering the back and sides of the body, arranged in longitudinal rows.

Keeled dorsal scales: those having a small median ridge lengthwise of the scale.

Rostral plate: the single, unpaired plate at the tip of the upper jaw.

Nasal plate: the plate in which the nostril is located. This may be a single plate completely surrounding the nostril or a pair of plates with the nostril between them.

Loreal: a small scale lying between the nasal and the preoculars.

Upper labials: the row of scales bordering the upper lip; those of the two sides of the upper jaw separated by the rostral.

Lower labials: the row of scales bordering the lower lip; those of the two sides of the lower jaw separated by the mental plate.

Preocular scales: one or more small scales directly in front of the eye. In a few instances these are wanting, then the scale touching the eye is longer than it is high and is called the loreal.

Postocular scales: one or more small scales just back of the eye.

Subocular scales: one or more small scales just beneath the eye between it and the upper labials.

Anal plate: the ventral scale located just in front of the anus. Designated as "divided" or "entire" depending on presence or lack of an oblique line dividing it.

Ventral scutes: the large transverse scales on the ventral side of the body extending from the head to the anus.

Subcaudals: the large scales on the under side of the tail, extending from the anus to the tip of the tail.

REFERENCES.

Blanchard, Frank N., 1925. A Key to the Snakes of the United States, Canada and Lower California. Michigan Academy of Science, Arts and Letters, Vol. IV. Part II.

Cope, E. D., 1900. The Crocodilians, Lizards, and Snakes of North America. Rept. U. S. Natl. Museum for 1898:153-1270.

Garman, H., 1892. A Synopsis of the Reptiles and Amphibians of Illinois. Bull. Illinois St. Lab. of Natural History, Vol. III, Art. XIII.

Stejneger, L. and Barbour, T., 1923. A Check List of North American Amphibians and Reptiles. Second Edition. Harvard Univ. Press, Cambridge, Mass.

A PRELIMINARY REPORT ON AN ECOLOGICAL PROBLEM IN THE ILLINOIS RIVER VALLEY.

LEWIS M. TURNER, CARLINVILLE, ILLINOIS.

The problem is concerned principally with an observation of the effects of alternate draining and flooding on the botanical content of the Illinois River valley. The river in question has suffered a variegated history in the past seventy-five years, in fact, there is probably no other river in this section of the country that has been as much altered and as much removed from its original, or we might say, its primitive condition.

The most outstanding alteration has been due of course to the construction of a series of deep-water-way dams. Between 1877 and 1892 four such dams have been completed; one at Kampsville, 45 miles from the river's mouth, one at La Grange, one at Copperas Creek, and one at Henry. In 1871 the Illinois Michigan Canal, and in 1900 the Chicago-Drainage Canal were completed and the diversion of Lake Michigan water was initiated. The presence of these dams and the addition of the lake waters materially increased the average height of the river and in the early nineties thousands of acres of the lower river bottom land were flooded. This motivated and occasioned the construction of a series of reclamation projects and rapid construction of levees began in 1892-1900. This is especially true of the area extending from Kampsville northward to Pekin and later to some extent in the neighborhood of Hennepin. Some areas were pumped out and drained a few years after flooding, some not until they had been submerged for periods of time varying from six to twenty years and in fact some are now in the process of reclamation. In many cases it is not practical to reclaim the drowned land and these tracts still lie under water just as they were twenty-five years ago.

It is obvious that the field presents a wealth of material for plant ecological research. Within a few square miles there are areas in which comparative studies can be made of a wide range of ecological conditions; from the primitive, unmolested condition, flooded and unflooded, through all

ages of reclaimed and cultivated land from twenty-five years to that very recently reclaimed. Fortunately for the investigator, but less happily for the valley land owners further field for research was made possible by the high waters of last Fall which broke the levees and submerged the enclosed area. In many cases there will be no attempt made to repair the damage, due to lack of money, and the once cultivated land will return to its condition before reclamation.

To facilitate study the investigator decided that a motor boat large enough to live in would be expedient. Such a boat was constructed in Carlinville, Illinois, and was trekked overland on a large hayrack, not with oxen, but with a farm tractor. Since the cruiser weighs almost three tons and is twenty-three feet in length, some rather interesting problems were encountered in its transportation and launching, but this was accomplished on June 25, 1927. The boat is fully equipt for cooking, eating, and sleeping, and there is sufficient room for research materials, and facilities are present for microscopic work, photographic developing and printing. A small auxiliary boat is carried for use in shallow water.

During the last summer several minor objectives were attained. First, a preliminary superficial survey was made of the entire field to gain an idea of the general set-up of existing conditions. This included a trip from a point 30 miles from the mouth of the river to a point four miles above Starved Rock which consumed approximately a month. Secondly, a detailed survey was made of the Kampsville area to secure specific information pertinent to the problem. This area was worked thoroughly as far as time permitted because it presents a representative and inclusive picture of the entire field. Third, a preliminary survey was made to determine the extent of water pollution as was evidenced by the presence or absence of aquatic plants. It was the hope of the investigator to find places in the river where plant life was distinctly and obviously impossible due to pollution from cities. Journeying northward from Kampsville there was no observed diminution in the shallow water aquatics until a point eight miles below Peoria was reached where the amount of plant life in the water fell off rapidly to practically nothing immediately below Pe-

oria. Above Peoria the unpolluted-water-condition existed and persisted up to Hall's Landing Light which is between Lacon and Hennepin and about 124 miles below Chicago: the principal source of pollution. This was practically the northern limit of aquatic plants other than algae; (no attempt was made to make a thorough examination of the Thallophytic content of the river). Although no particular effort was directed in this direction, algae were certainly not conspicuous except for one species of Spirogyra which was found sparingly as far north as Starved Rock.

The point of total absence of aquatic plants was farther north than the investigator anticipated. This might be partially explained by the higher level of the river and of the greater dilution of the sewage due to the rains of August. The plants used as indicators of the condition of the water were as follows: *Potomogetans*, Polygonum, Sedges, Sagittaria, *Lemna*, Spirodela, *Ceratophyllum*, Hibiscus, *Vallisneria*, *Elodea*.

It is the intention of the investigator to spend at least two more summers in pursuit of the problem.

THE STARLING.

G. N. HUFFORD, JOILET TOWNSHIP HIGH SCHOOL, JOLIET, ILLINOIS.

On December 16, 1926, Mr. Lester Corrie of Joliet, Illinois, killed, what he thought to be a flicker, at the eastern outskirts of the city. Upon closer examination he realized that it was not a flicker and, as he had never seen a bird like it before, he took it to the Joliet Township High School for identification. He showed it to Mr. C. E. Spicer, Assistant Superintendent of the high school and he, being an ardent bird student, at once recognized it as a starling (Sturnus vulgaris Linn.) Mr. Corrie presented the bird to Mr. Spicer who had it mounted, and it is now a valued specimen in the High School Museum.

At that time we believed this bird to be the only starling to have been found in Illinois. Recently, however, Mr. O. M. Schantz, President of the Illinois Audubon Society, informed me that Mr. Wm. Lyon, President of the Inland Bird Banding Association, had trapped two starlings. Mr. Lyon confirmed this, saying that the two birds were caught in his traps at Waukegan, Illinois, in December, 1925. He banded both birds and released them, but to date neither of them has been heard from. Neither Mr. Schantz nor Mr. Lyon knew of any other starlings having been found in this state. Mr. Lyon tells me that at least one has been killed in Wisconsin, the specimen now being in the Milwaukee Museum. Mr. Spicer told me that he had heard that the bird had been reported in Iowa but I have not been able to verify this report. In December, 1926, Mr. Amos W. Butler, President of the Indiana Audubon Society reported to the Indiana Academy of Science that three starlings had been killed in that state during that and the preceding year.

These few birds found recently in our neighborhood are probably the forerunners of what bids fair to be the greatest bird invasion of our time.

The Starling is a European bird. At least three attempts have been made to introduce the species into the United States. The first attempt at Cincinnati, Ohio, and the second at Portland, Oregon, were failures; but the third

attempt at New York City was highly successful. Approximately one hundred starlings were released there in 1890 and 1891. From these the species has multiplied and spread until it has become as common in the eastern states as its fellow countryman, the English Sparrow. It has been spreading in all directions from New York but especially to the west in states of the same latitude. At present its western breeding limit is probably in western Ohio. In the field reports for Bird Lore for December, 1926, we find the following: Observers in New York reported 7079 starlings; observers in New Jersey reported 3999; Mass., 1590; Pa., 1122; R. I., 488; Va., 375; Ohio, 341; Vt., 78; Me., 46; N. H., 26; Md., 25; Mich., 4. In no other states were any reported. These are the numbers of birds seen by a few observers during trips of a few hours each. One observer in New York estimated one flock at 3500. Another noted that there were more starlings than there were English Sparrows. These figures give an idea of the numbers of starlings in the east.

Up to the present time the economic status of the starling has not been determined, but the weight of eastern opinion seems to be against him.

Two conclusions are warranted. The first is that the starling has become firmly established as a member of our bird fauna. The second is that the species is spreading westward at rather a rapid rate. We may reasonably expect to hear of other starlings being found in Illinois during the present year. And we should study them carefully from their earliest appearance in order to determine what their coming will mean to us biologically and economically.

CYNIPID GALLS OF THE CHICAGO AREA.

LEWIS H. WELD, EAST FALLS CHURCH, VIRGINIA.

The cynipid fauna of the Chicago area is probably better known than that of any other American locality. For this reason it seems desirable to collect the descriptions of the galls of this area from the scattered technical literature that they may be available for the use of biology teachers not only in this area but in all northern Illinois, Indiana and Ohio as well as southern Wisconsin and Michigan. In this field lies much readily accessible illustrative material for biology teaching and any number of original problems in the working out of life histories and the interrelationships of the many various species sometimes associated in a gall. These descriptions have been considerably condensed and grouped first by host plants and then by part of plant affected and it is hoped that this may serve as a means for the determination of the galls of this area. How successful it may be in accomplishing this purpose only time and its continued use in the field can tell. To make it as complete as possible several galls are included which have not as yet been determined or reared and which are probably undescribed. Field observation will no doubt find still other kinds and add other hosts to those already known.

For the beginner in the study of insect galls it may be well to state that this treats only of the galls made by the true gallflies, or the family Cynipidae of the order Hymenoptera, whose galls are principally on oak but some occur on roses and a few other plants in the rose family and a few on various composites as will be seen in detail later, the record of the one reported on *Smilax* being questionable. These hosts often bear at the same time galls made by other agents e. g. by mites, aphids, psyllas, gall midges, trypetid flies or moths and some field experience will be necessary before one can assign the maker of the gall to its proper group. In general however the Cynipid galls may be recognized by being closed in every case and containing white, non-hairy larvae of characteristic shape soon learned by experience.

From a collection of galls from the field and placed in rearing, insects belonging to one or more of four classes are liable to be secured.

(1) The Cynipid maker which stimulated the plant to form the gall and which, having passed through the earlier stages of its life within, chews out as an adult to lay its eggs and die.

(2) Commensals which feed on the tissue of the gall. If the commensal is a beetle larva or a caterpillar no change is produced in the gall. But there are five genera of Cynipids which, unable themselves to stimulate a plant to form a gall, lay their eggs in the peripheral parts of a gall already started and cause it to become more or less deformed. This deformation may or may not kill the larva of the maker of the gall. The larvae of some species of one of these—*Synergus*, after feeding on the plant tissue, are known to break their way into the central cell and parasitize the maker. These five genera are often called guest flies or inquilines and were often mistaken by the early entomologists for the maker of the gall. These guest flies always leave the gall later than the maker.

(3) Parasites and hyperparasites such as chalcids, braconids, ichneumons etc., which feed upon the body of the maker or of a guest fly or on another parasite.

(4) Successors or lodgers which utilize an empty gall as a nest or simply as a shelter or place of hibernation.

The beginner in the study of the gall-making Cynipidae is handicapped and often discouraged by the lack of published information as to the date of emergence of the maker of the gall. Not knowing at what time of year to collect the galls to get the maker, he rears nothing or gets only guests or parasites. Some general suggestions on rearing methods, applying only to Cynipid galls however, may be of value. Galls on herbaceous plants like *Fragaria*, *Potentilla*, *Nepeta*, *Silphium*, *Ambrosia*, *Lactuca* and *Prenanthes* may be collected in the fall if they can be put where they will not dry out too much but are better left in the open all winter and brought into the laboratory in the spring. A pasteboard box with a vial or test tube in one side makes a convenient breeding cage. Many galls on shrubby plants like *Rosa*, and *Rubus*, may be treated in the

same way. The succulent vernal galls on the leaves, buds or the flowers of oak must, however, usually be left on the tree until the larvae within use up all the nutritive layer of plant tissue and transform into pupae but such species develop rapidly and it is a matter of leaving them some days or at most but a few weeks longer. When the larvae are about mature or the pupa stage is reached, twigs bearing such galls can be put in a bottle of water and cotton plugged tightly around the stems at the mouth of the bottle so that the emerging flies can not crawl into the water and become drowned. This bottle should then be set in a battery jar with muslin tied over the top—if set under a bell jar the condensation water on the glass will wet the wings of the emerging flies. From galls of this type come fully-winged, active adults of both sexes whose adult life is short, a few days at most.

The more solid autumnal galls on oak, maturing and dropping just before or with the leaves, contain at that time, which is when they are usually gathered, a scarcely visible larval cavity in a thick translucent nutritive layer which is used up slowly during the winter. Such galls should be kept under more or less natural conditions out-of-doors on the ground in some sort of a wire cage. Select a shady spot in the woods if possible where there is a deep layer of leaf mold, safe from molestation and from fire in summer and well buried under snowdrifts in winter. Mice and squirrels are liable to destroy collections unless wire cages are used. Labels inside should give locality, date and host and may be written with waterproof ink on paper and then dipped in melted paraffin or better enclosed in a well-corked 7 by 25 mm. vial. The year of collection should not be omitted in the date. Two winters often pass before any flies appear and then some may emerge each spring for several years. The larvae transform in the fall before they emerge and remain in the galls as adults during the winter to come out when conditions are suitable in the spring. Adults may often be secured by cutting open galls in the late fall or winter but in this case it is better to let them crawl about in a vial until the chitin hardens and takes on its normal color rather than to kill them at once in a cyanide bottle. Adults from

galls of this type are all agamic females and are comparatively long-lived, often surviving for a month or more in captivity. Many species normally emerge in late fall, for example all those of the genus *Disholcaspis*, (whose galls on twigs are in general bullet-shaped, detachable but not deciduous) and many wingless agamic forms such as species of *Acraspis*, *Xanthoteras*, *Zopheroteras*, etc. Some woody stem swellings on oak become so hard after being gathered that the insects even if they have already transformed can not chew their way out and it is necessary to cut them out. These are but general suggestions for the beginner and their value is indicated by the fact that the writer knows many kinds of galls which he has never yet been able to rear. A single gall casually collected is seldom worth the trouble of rearing. It may be the normal reaction of the plant to the stimulation of the Cynipid maker or it may be quite abnormal if that structure is modified by the attacks of guest flies or parasites and some field observation may be necessary to determine whether this is the case. Collecting to be of value usually requires definite search for quantities of material with the object of rearing in view. When gathering galls from the ground in the fall especial care must be taken to see that no galls of other kinds are included in the breeding cages.

For a number of years the writer lived at Evanston, Illinois and collected galls either within the city limits or along the north branch of the Chicago river four miles west or along the "north shore" as far north as Waukegan with occasional trips to the sand dune area at the southern end of Lake Michigan in Indiana and less frequent trips to the general region of the "sag" south-west of Chicago. In this Chicago area the writer found a total of 124 species of gall-making Cynipidae and in addition has field notes on some 30 other galls from this area either not determined or not reared, some of the more conspicuous of which are included in this paper. Further collecting will no doubt yield still other species for during the last year of residence there it was no unusual experience to find galls that years of previous collecting had never discovered. Moreover collecting on three of the nine oaks in the region was very fragmentary, these being seen hardly more than once or twice a

year. Strangely enough the only species previously described from this area the writer has never been able to find although he has looked for it for years. This is *Diastrophus smilacis* Ashmead, described from "Chicago" in 1896 as producing a gall on *Smilax*. The oak openings at the edge of the prairie now transformed into the suburbs of a densely populated metropolitan district would not be suggested as an ideal region for Cynipid collecting and yet it will be interesting to compare its 125 species with the few published local lists available. In 1904 Beutenmueller listed 46 of the more conspicuous Cynipid galls in the vicinity of New York City. Stebbins listed 66 from Springfield, Mass. in 1910. Sixty-four are known for the Toronto area.

It is to make available to students of this group the writer's experience with those species of the Chicago area that have been reared or are felt to be determined with some certainty from the galls that this paper has been prepared. The emergence dates given apply to the Chicago region. Some variation will be found from year to year depending on the earliness or lateness of the season.

The generic names here used are in general those of the latest monograph on the Cynipidae, that of Dalla Torre and Kieffer, published in 1910 as Lieferung 24 in Das Tierreich. Those already somewhat familiar with generic names in this group will notice that *Disholcaspis* is now used for *Holcaspis* and *Diplolepis* instead of *Dryophanta*. The names used for the oaks are those of the seventh edition of Gray's Manual.

Gall on Smilax.

Described as irregularly rounded, abrupt pithy swellings on stem, one inch long by one-half inch in diameter. Polythalamous. Described from Chicago in 1896 and not collected since. Specimens much desired. It is suspected that there is an error here in the identification of the host plant. The adults are said to have emerged in Jan. and Feb. but the type flies in the National Museum bear the date label of May 1-8.

1. *Diastrophus smilacis* Ashm.

Gall on Fragaria.

STRAWBERRY PETIOLE GALL. A cylindrical gall on the petiole of a leaf, 20-60 mm. long by about 5 mm. in dia-

meter, containing 8-20 cells, red in summer, turning brown later. Flies emerged June 2, 1918.

2. *Diastrophus fragariae* Beut.

Galls on Potentilla.

Fusiform or cylindrical swelling of stem or peduncle, 10-35 mm. long by 5 mm. in diameter. Polythalamous. Adults emerge Apr. 15-May 1.

3. *Diastrophus niger* Bass.

CINQUEFOIL AXIL GALL. Globular, 8-13 mm. in diameter, in axils of leaves, green in summer with rudiments of leaves at apex, fleshy, spongy within, turning brown later. Monothalamous. Flies emerge the latter half of May.

4. *Gonaspis potentillae* (Bass.)

Galls on Rubus.

On blackberry.

BLACKBERRY SEED GALL. Cluster of reddish-brown, seed-like bodies closely set about the stem sometimes for several inches, the cluster being on the weaker canes about a foot or so from the ground, each seed-body bearing several filaments and monothalamous. Adults begin to emerge early in June.

5. *Diastrophus cuscutaeformis* O S

BLACKBERRY KNOT GALL. Abrupt, elongated, pithy, subterminal stem swelling, 1-3 inches long by an inch in diameter. Surface uneven with irregular tubercles or longitudinal grooves, green or reddish-brown. Polythalamous. Adults probably emerge early in June. Not common in Chicago area.

6. *Diastrophus nebulosus* (O S)

On raspberry.

Abrupt stem swelling, up to 65 mm. long by 30 mm. in diameter, densely covered with short prickers, green in summer, turning brown later, polythalamous. The flies emerged May 1-15, 1912.

7. *Diastrophus turgidus* Bass.

Galls on Rosa.

"Root" galls.

Deeply incised on top. Diameter up to 55 mm. When mature light in weight, of a brittle spongy texture within

with large deeply imbedded larval cells. The makers issue in May.

8. *Rhodites utahensis* Bass.

Irregularly lobed, not incised, smaller, tissue more compact, adults emerging later in May or early June.

9. *Rhodites semipiceus* (Harris)

Stem galls.

Fusiform stem swelling up to 50 mm. long by 13 mm. in diameter, densely covered with prickers, rarely smooth. Polythalamous. Adults emerged May 27-June 21, 1909.

10. *Rhodites dichlocerus* (Harris)

Smaller fusiform or abrupt one-sided corky enlargements of the stem, up to 30 mm. by 7 mm., with a longitudinally fissured brown surface. Polythalamous. Flies emerged May 15-June 15.

11. *Rhodites fusiformans* Ashm.

Abrupt, irregularly lobed, subterminal stem swellings, up to 35 mm. in diameter, densely covered with sharp spines. Reddish-brown. Contain 30-50 cells arranged radially along the long axis. Adults emerged Apr. 27-May 13, 1915.

12. *Rhodites multispinosus* Gill.

Scarcely noticeable enlargement at base of small lateral branches bearing many leaf scars, the distal end of twig dead. Contains up to 5 larval cells but usually only one. On sweetbriar. Adults emerged May 25 until early in June.

13. *Rhodites nodulosus* Beut.

MOSSY ROSE GALL. A globular mass of mossy green filaments appearing in June and turning brown later. Polythalamous. Adults emerged Apr. 27-May 4, 1907. An European species most common on the introduced sweetbriar rose but occasionally found on *Rosa rugosa*.

14. *Rhodites rosae* L.

Leaf galls.

SPINY ROSE GALL. Globular, 8-10 mm. in diameter, 3-10 in a cluster, the leaf obliterated if the cluster is large, covered with numerous tapering spines about as long as the diameter of the gall. Succulent in summer, often tinged

with red, turning brown and persisting through the winter. Monothalamous, cavity large, wall over 1 mm. thick. Flies emerge in May.

15. *Rhodites bicolor* (Harris)

Similar but smaller, 4-5 mm. in diameter, covered with short weak spines, wall thin. On upper side of leaflets near margin, dropping with the leaves. Flies emerged May 24. Galls of this type need further study as there may be more than one species.

16. *Rhodites pustulatoides* Beut.

MEALY ROSE GALL. Globular, up to 15 mm. in diameter, several often coalescing into a mass, covered with a mealy white efflorescence. Hard, polythalamous, attached to the under side of leaf. Adults emerge about the middle of April.

17. *Rhodites ignotus* O S

REGAL ROSE GALL. Globular with a flattened top like that of a patty-pan squash, single or in clusters on under side of leaflets. Diameter 5-6 mm. Dropping with the leaves in the fall. Adults emerge May 15-June 10.

18. *Rhodites gracilis* Ashm.

ROSE LENTIL GALL. A lentil-shaped hard thickening of the parenchyma of the leaf, green, more convex on lower surface, single or in small groups, 3 mm. in diameter. Drop with the leaf. Adults emerged May 11-June 14.

19. *Rhodites rosaefolii* Ckll

Gall on Nepeta.

Globular, green, fleshy, 8-11 mm. in diameter. Galls turn brown in Aug., the larvae transforming in Sept., the adults remaining in the galls over winter and emerging in the spring. An introduced European species on the introduced European host plant *Nepeta (Glechoma) hederacea*, Gill-over-the-ground.

20. *Aylax glechomae* (L.)

Galls on Silphium.

Cells in a small group hidden in among the disk florets in the flower head and found only when the head is broken open. Adults emerge in the spring, probably in May.

21. *Aylax laciniatus* Gill.

Cells in the pith with no external evidence until the exit holes are seen. Adults of two species emerged May 15-June 24.

22. *Aylax rufus* (Gill.)
23. *Aylax gillettei* (Kieffer)

Gall on Taraxacum.

DANDELION GALL. Irregular fusiform or nodular swellings on petiole, base of peduncle or scattered along the midrib. Green and fleshy in June, after maturity becoming dry, brown and pithy. Polythalamous. Adults emerge the next spring about June 1. Another European species on an introduced European host plant.

24. *Aylax taraxaci* (Ashm.)

Galls on Lactuca.

LETTUCE TUMOR GALL. Fusiform pithy stem swellings, high up on stem, bearing many leaves or branches of the panicle. Diameter up to 30 mm., polythalamous. Adults emerged May 4-June 1.

25. *Aulacidea tumida* (Bass.)

Knotty enlargements scattered along the stem at base of leaves. Polythalamous. Flies emerge early in June.

26. *Aulacidea podagrae* (Bass.)

Cells in the pith—no external evidence until exit holes are made in the spring. Flies emerge the first week in June.

27. *Aulacidea harringtoni* (Ashm.)

Gall on Prenanthes.

Abrupt hemispherical swellings just below the surface of the ground at base of plant, often so grouped as to surround the stem, resembling a raw potato in consistency in summer, becoming corky in fall. Polythalamous. Flies emerged June 8-11.

28. *Aulacidea nabali* (Brodie)

Galls on Quercus.

A. "Root" galls - - - - - - p.
B. Acorn galls - - - - - - - p.
C. Flower galls - - - - - - p.
D. Bud galls - - - - - - - p.
E. Stem galls - - - - - - - p.
L. Leaf galls - - - - - - - p.

A. Galls on the "roots."

1. True root galls, found on the small fibrous rootlets covered with an inch or two of leaf mold underneath large forest trees.

Single or in small clusters, ellipsoidal, brown, 5 mm. long, wall thin and fleshy, monothalamous. On *Q. bicolor*. The larvae transform in the fall after the nutritive layer has been used up, the flies emerging the next spring between Apr. 15 and May 7. They are all females and oviposit at once in the swelling buds of the same tree but the alternating sexual generation is unknown.

29. *Callirhytis ellipsoida* Weld

Similar on *Q. alba*. Flies of this species were taken ovipositing in buds of *Q. alba* on May 11.

30. *Callirhytis elliptica* Weld

2. Irregularly globular, abrupt, subterranean stem swellings at the base of sprouts from stumps. Woody, 10-30 mm. in diameter, polythalamous, the cells just underneath the bark which is not greatly thickened, the bark bulging slightly over a cell causing the surface to present a pebbled appearance. Adults probably emerge in the spring. On *Q. coccinea* and *rubra*.

31. *Eumayria floridana* Ashm.

3. Cells imbedded in the greatly thickened bark at the crown of the tree.

Occurring in large numbers forming hypertrophied patches of considerable area without sharply defined limits.

On the main roots of trees of *Q. alba*, the flies emerging in spring (May 12, 1917) to oviposit in the swelling buds on the same tree. See 115.

32. agamic gen. of *Callirhytis futilis* (O S)

At the base of saplings of *Q. macrocarpa*, causing a swelling 4-5 times the normal diameter and extending for nearly a foot sometimes. Flies emerge in early Nov.

33. *Compsodryoxenus illinoisensis* Weld

Occurring in small groups of less than a dozen usually, sometimes single.

Cells in thick brown bark forming an abrupt local swelling, these hemispherical swellings sometimes confluent and surrounding the stem. At the base of stumps or

trees. Polythalamous, the number of cells within more or less evident. Adults probably emerge in the spring as the larvae transform in the fall. On *Q. rubra* and *coccinea*.

34. *Callirhytis rubida* Weld

Similar local swelling, the number of cells within not so apparent. Single or confluent, on sprouts or saplings of *Q. coccinea*. Adult emerged April 25. They oviposit in the swelling buds of the same clump of sprouts at whose base the galls were found.

35. *Callirhytis marginata* Weld

4. Detachable galls or masses of galls at the crown.

Single or scattered about in small numbers.

Hemispherical, 10-15 mm. in diameter, rugose to nearly smooth, covered with normal brown bark, leaving a radiating scar when detached, woody when mature, monothalamous. At base of thrifty sprouts from stumps of *Q. alba, bicolor* and *macrocarpa*. Transformation takes place in the fall, an adult emerging April 28, the emergence probably distributed over a period of two years. The flies oviposit in buds of vigorous white oaksprouts but alternating generation is unknown.

36. *Callirhytis badia* (Bass.)

Large, polythalamous, rounded masses, up to 90 mm. long, growing out of one side of main root at base of tree or stump. When mature the interior resembles well-rotted wood in which scattered hard, thin-walled, brittle, brown larval cells are imbedded. Light as cork when dry. On *Q. alba, bicolor* and *macrocarpa*. The larvae transform in the fall, the adults emerging the next spring in late April.

37. *Callirhytis maxima* Weld

In clusters of separable elements.

Pure white or rosy when fresh in May, fig-shaped, polythalamous, fleshy, decaying or shriveling up after the emergence of the adults, June 12-26. Frequently at base of stumps of *Q. alba* on whose sprouts the oak fig gall was formed the fall before. See 83.

38. *Trigonaspis radicola* (Ashm.)

Gall not transitory and fleshy but more or less woody and persistent.

Individual galls less than 6 mm. in diameter.

Cluster spherical or elongated, 20-25 mm. in diameter, consisting of 30-150 galls, 4 by 6 mm., roughly ellipsoidal, faintly grooved. They contain adults in the fall which probably emerge some time in the spring. On *Q. rubra* in the fall at the base of sprouts.

39. *Callirhytis enigma* Weld

Clusters spherical, up to 60 mm. in diameter, made up of as many as 400 elongated wedge-shaped bodies resembling long kernels of corn. Monothalamous, the larval cell in the basal part of the gall. Adults emerge in Dec., Feb. and March. On *Q. rubra* and *coccinea*.

40. *Dryocosmus favus* Beut.

Clustered at base of vigorous sprouts, up to 30 in a group, onion-shaped, 5-8 mm. long, pointed at apex, longitudinally striate, brown, hard and brittle when mature in the fall, monothalamous. Often enclosed in a "shed" by ants which are fond of the honeydew the growing galls secrete. On *Q. ruba* and *velutina*. Adults emerge in the late fall, Nov. 23-Dec. 2.

41. *Biorhiza caepuliformis* (Beut.)

Individual galls averaging over 7 mm. in diameter.

Globular bullet galls with a distinct inner cell often free in an irregular cavity within. Up to 40 in a cluster at base of sprouts from stumps of *Q. alba*. Adults emerge in late Oct. and early Nov.

42. *Disholcaspis globosa* Weld

B. Galls on acorns.

1. Galls on or in the tissue of the cup not involving the acorn proper.

ACORN PLUM GALL. Globular, 15-25 mm. in diameter, hard, mottled brown or reddish, attached on side of acorn cup and dropping to ground in the fall. Monothalamous. Adults issue in the spring, the emergence distributed over a period of several years. On *Q. rubra, velutina* and *coccinea*.

43. *Amphibolips prunus* (Walsh)

FIMBRIATE CUP GALL. A smooth elongated gall, 4 by 7 mm., partly imbedded in a fimbriate depression in the side

of the acorn cup and slipping to the ground when mature in the fall. On *Q. bicolor*. Flies emerge the second and third springs Mar. 25-Apr. 18 and oviposit in buds of *Q. bicolor*. Alternating generation unknown.

44. *Andricus incertus* Bass.

Cell in the tissue of the cup and not separable from it directly underneath the acorn causing it to become lopsided. On *Q. bicolor* in the fall.

45. *Undescribed species*

2. Galls of the type known as "pip" galls produced between the acorn and the cup, always on red oaks.

Pip galls alongside full grown acorns of *Q. rubra* slipping out to the ground in late summer. Adults emerging in late Apr. or early May the second spring. See 53.

46. agamic gen. of *Callirhytis operator* (O S)

Pip galls alongside immature acorns.

On *Q. coccinea* in spring as buds are swelling, on the partly grown acorns of the previous season. Fleshy, smooth, greenish mottled with purple, laterally compressed, rounded at end and secreting honeydew. Monothalamous. Drop in May. Adults emerge the second and third springs Apr. 22-May 11.

47. *Callirhytis balanosa* Weld

On *Q. velutina* in fall on small acorns of current season, sometimes 2-3 on one acorn, secreting honeydew. When detached somewhat triangular, flattened, the larval chamber transversely placed in upper half of gall. Flies issue early in May the second spring.

48. *Callirhytis balanoides* Weld

On *Q. velutina* and *rubra* in fall on acorns of the current season. Globular, color green to tan, 3-4 mm. in diameter.

49. *Undescribed species*

3. Galls inside the acorn.

ACORN STONE GALL. Cells thick-walled and coalescing into a stony-hard mass which more or less fills the interior of the acorn so that the cotyledons are reduced or absent. On *Q. rubra* and *coccinea* in the fall. Adults emerge in early May the second and third springs.

50. *Callirhytis fructuosa* Weld

Cells separable and with thin walls.

On *Q. bicolor.* Cells in a group of as many as 15, shaped like apple seeds, underneath or slightly to one side of the cotyledons, causing the acorn to bulge somewhat on one side. Occurs in fall in large acorns. Flies issue Apr. 25-May 16 the second and third springs.

51. *Callirhytis lapillula* Weld

On *Q. alba.* Similar, less common.

52. *Undetermined species*

C. Galls on the staminate flowers.

Woolly white mass on the flowers of *Q. rubra, velutina, coccinea* and *imbricaria* becoming tan colored as it matures in late June when the insects emerge and oviposit in the one-year-old acorns to produce the pip galls in the late summer. See 46.

53. sex. gen. of *Callirhytis operator* (O S)

Pea-shaped, smooth, green, bare, fleshy, scattered in small numbers along the flower axis, dropping with the flowers in late May or early June. Contain 4-5 cells. Flies emerge early in June of the same season. On *Q. rubra* and *coccinea.*

54. *Callirhytis pulchra* (Bass.)

D. Bud galls.

(Galls which are quite obviously modified buds and hence arising at definite places on the stem such as at the nodes, in the axils of the leaves or developing and sometimes hidden in the inside of buds. Detachable and often deciduous when mature.)

1. Over 10 mm. in diameter or in length.

Large, globular, spotted, with a thick outer wall and a central cell supported by stout radiating fibers, 11-13 mm. in diameter. In axils of leaves of large trees of *Q. rubra,* dropping about the middle of Sept., after which they turn brown and the surface becomes characteristically wrinkled. Brodie says that in Toronto adults emerge late the next Oct., all females, and oviposit in buds. Male unknown.

55. *Amphibolips cookii* Gill.

Cylindrical, 5 by 14 mm., tapering toward the blunt ends, mottled. In early spring from weak lateral buds on *Q. palustris* and *imbricaria*. Deciduous. The fly probably emerges early the next spring as one was found dead in breeding cage April 10.

56. *Amphibolips ellipsoidalis* Weld

Gall slender, elongated, fusiform, long-stalked, longitudinally grooved, up to 31 mm. long. Found in late summer sticking out obliquely upward from weak lateral buds on current season's growth, dropping in early Sept. Adult emerges the second spring after, probably in Apr. or May. On *Q. rubra*.

57. *Callirhytis gallaestriatae* Weld

2. Under 10 mm.

Gall almost wholly exposed, not much concealed by the bud scales.

Spherical, smooth, bare, milky-white mottled with purple, consisting of a thin fleshy layer outside a hard brittle brown shell. Diameter 3-6 mm. monothalamous, deciduous. Occurs as buds are opening in spring on *Q. alba, bicolor* and *macrocarpa*. The larvae transform in late fall, the adults emerging in spring.

58. *Andricus pisiformis* Beut.

Spherical, slightly elongated at apex, 4 mm., greenish-gray with longitudinal purple streaks, monothalamous. Develop from weak lateral buds near base of season's growth or from dormant buds on older twigs. After they drop about the end of Sept. the thin fleshy outer layer rots away leaving a hard thin-walled shell. Adults emerged the second spring on April 10. On *Q. bicolor*.

59. *Andricus deciduatus* Weld

Globular or kidney-shaped, thin-walled, fleshy, green or brownish, 3-5 mm. in diameter. Monothalamous. Usually occurs in terminal bud cluster in Mar. or Apr. as buds begin to swell, the flies emerging as the buds open in early April. On *Q. alba, bicolor* and *macrocarpa*.

60. *Neuroterus vesicula* (Bass.)

Conical, white or tan-colored, 3 mm. high, wall very thin and brittle. In the terminal cluster of buds in spring,

flies are said to emerge in Conn, in the middle of May. On *Q. alba*, and there is a similar gall perhaps made by the same species on *Q. bicolor* and *macrocarpa*.

61. *Diplolepis gemula* (Bass.)

Conical, greenish becoming brown when mature, 3-4 mm. high, from weak dormant buds on limbs or from adventitious buds on trunk of large trees of *Q. alba* in Sept. and Oct. Deciduous. Adults emerge the second spring, transforming the fall before.

62. *Callirhytis gemmiformis* (Beut.)

Fusiform or ellipsoidal, 3 by 5 mm., greenish when young becoming yellowish with rosy stripes and covered with stellate hairs, monothalamous, the wall thin. At apex there is a slight papilla surrounded by a circlet of reflexed hairs. From weak lateral buds at base of branches on strong sprouts from stumps in May in clusters of from 2-8, deciduous. Flies emerge early the next spring probably in April. On *Q. coccinea*.

63. *Callirhytis rugulosa* (Beut.)

Melon-shaped, with longitudinal grooves like some types of cantaloupe, 3-4 mm., rose-pink, with a small tuft of hairs at the apex. On *Q. velutina*. Found but once—on May 1. Not reared.

64. *Undescribed species*

Gall at least half concealed by the bud scales about its base.

Smooth, greenish, 3 mm. high, ribbed, in June, the bud scales developing into leafy bracts which after the gall is pushed off to the ground in July become more and more leaflike and form a compact persistent mass conspicuous in winter. In terminal buds of *Q. bicolor* and *macrocarpa*, on vigorous sprouts. Adults probably emerge the next spring.

65. *Callirhytis flavohirta* (Beut.)

Greenish-brown, smooth, globular with a papilla at apex, half protruding beyond the normal bud scales. In buds of terminal cluster in the fall. On *Q. alba*. Adults emerge the second spring.

66. *Callirhytis mamillaformis* Weld

Similar on *Q. bicolor* and *macrocarpa* in the fall.

67. *Undetermined species*

Similar on *Q. rubra* in the fall.

68. *Undetermined species*

Similar on *Q. coccinea* in early spring, smooth, polished, tan-colored, scarcely protruding.

69. *Undetermined species*

Found under large trees of *Q. coccinea* in May and probably bud galls. Globular, slightly compressed, with a scar and short stalk at base, a linear indentation at the apex, no nipple, 3 by 4 mm., brownish or purplish, mottled.

70. *Undetermined species*

Gall a blister on the inner concave face of bud scale, not visible until bud is dissected, wall thin, brittle, white or tan-colored. But one or two on a scale. Occurs as buds open in early spring on trees of *Q. alba* where the hedgehog gall was found the previous fall. Adults issue early in May. See 126.

71. sex. gen. of *Acraspis erinacei* (Beut.)

E. Stem galls.

(Not obviously derived from buds.)

1. Cells in the twigs, no deformation evident.

Cells in the tissue of the twig under leaf scar, the tip protruding so slightly as to be scarcely visible until the adult begins to chew its way out in the latter half of April. Sometimes two cells under the same leaf scar. Near the terminal cluster of buds on *Q. bicolor.*

72. *Neuroterus escharensis* Weld

Cells scattered along the internodes in the wood under the normal bark. Date of emergence unknown. On *Q. coccinea.*

73. *Bassettia ceropteroides* (Bass.)

2. Woody, persistent, polythalamous stem swellings.

HORNED KNOT GALL. Abrupt irregular mass up to 2 in. in diameter covered with normal bark and consisting of tissue which cuts like cheese until the galls are full grown about the middle of May; then long, pointed horns begin to

protrude from the surface and drop to the ground early in July. Each is cylindrical, 2 by 8 mm., with a larval cell at base, the adults emerging the next spring early in May. The twig beyond the gall dies and the gall becomes woody and persists on the tree for years. On *Q. rubra.*

74. *Callirhytis cornigera* (O S)

OAK KNOT GALL. Irregularly lobed, confluent stem swellings sometimes encircling twigs for several inches and eventually killing the twig beyond that point. Up to 40 mm. in diameter, covered with normal bark, polythalamous. Full grown by middle of June, the larvae transforming to adults in late fall, the adults emerging the next spring in April or May—all females. On *Q. rubra, coccinea* and *velutina.*

75. *Callirhytis punctata* (Bass.)

OAK POTATO GALL. Irregularly fusiform, tuber-like stem swellings, 10-40 mm. long by 15 mm. in diameter, deforming the terminal twigs of small trees or sprouts of *Q. alba.*

In spring at base of the new growth, fleshy, green, glaucous, the adults emerging the latter half of June. See 77.

76. sex. gen. of *Neuroterus batatus* (Fitch)

In winter a similar but woody gall covered with normal brown bark, the adults emerging the latter half of April and ovipositing in the buds. See 76.

77. agamic gen. of *Neuroterus batatus* (Fitch)

NOXIOUS OAK GALL. Irregular woody enlargement at or near the ends of twigs on trees of *Q. bicolor,* up to 40 mm. long by 25 mm. in diameter, covered with normal bark, polythalamous, conspicuous on the trees in winter. The adults emerge in early April and oviposit in the buds just as they are beginning to swell. See 104.

78. agamic gen. of *Neuroterus noxiosus* (Bass.)

OAK CLUB GALL. Terminal, club-shaped, about 15 mm. in diameter with several leaves growing from it, containing one to three larval cells. Green while growing but becoming brown and woody after the escape of the adults in early July, the old galls persisting for years. On trees of *Q. alba.*

79. *Callirhytis clavula* (O S)

Abrupt enlargement at end of the new growth on *Q. coccinea* in June, checking the growth in length and bearing several leaves, the internodes short. Green, about 15 mm. in diameter at base and gradually tapering above. Usually several in close proximity on the tree. Adults emerge in early July.

80. *Callirhytis scitula* (Bass.)

Slight enlargement on one side of the new growth of *Q. bicolor* in early May causing the branch to be dwarfed and bent over to one side, green, polythalamous, the flies emerging about the middle of May.

81. *Neuroterus distortus* Bass.

3. Detachable and often deciduous.

OAK SEED GALL. A globular or elongated woolly or spongy white mass often tinged with spots of pink, 20-30 mm. in diameter, consisting of numerous slender fusiform bodies attached by one end to a common point on the twig —probably a bud gall morphologically. Each seed-like body contains one larval cell and the distal part bears the white filaments. Occurs on trees of *Q. alba*, starting about the middle of May, the adults emerging June 29-July 12.

82. *Callirhytis seminator* (Harris)

OAK FIG GALL. A cluster of tan-colored, hollow bodies surrounding the twig for several inches at or near its upper end and occasionally scattered along the midrib of leaves, the diameter of the cluster about one inch. On strong sprouts from stumps of *Q. alba* in the fall and within reach from the ground. Individual galls are much distorted by mutual pressure, monothalamous, the larval cell in the base surrounded by fine radiating fibers. Appear about the end of June. Adults emerge on thawing days in Dec., Feb. and March, all females and wingless. Is suspected of being the agamic form of *Trigonaspis radicola* (Ashm.) See 38.

83. *Xanthoteras forticornis* (Walsh)

PINE-CONE OAK GALL. Globular cluster, up to 35 mm. in diameter, at end of twig, consisting of 25 or more wedge-shaped bodies attached by their tapering bases to a common point on twig. Hard, breaking off easily when mature, brown, monothalamous, dropping in the fall. Some flies

emerge in the spring for at least three seasons. On *Q. bicolor* and *macrocarpa.*

84. *Cynips strobilana* O S

Globular cluster of fig-shaped galls on one side of the twig on strong shoots of *Q. coccinea* in May, the cluster made up of about a dozen or more galls, each 15 mm. long by 10 mm. in diameter, green, fleshy, monothalamous, the distal end blunt with a depression in the center. They turn brown and drop off in summer. The larvae transform in the galls in the fall, the adults probably emerging in early spring.

85. *Andricus formosus* (Bass.)

Seed-like bodies in rows bursting out of longitudinal cracks in the bark of vigorous young shoots in late summer, dropping to the ground in the fall. The individual galls are lenticular in shape with a scar at the base, about 6 mm. long, hard, smooth and polished. Ashmead reared the type flies from galls from N. Carolina on June 6. On *Q. imbricaria* and probably other red oaks.

86. *Andricus excavatus* Ashm.

ROUND BULLET GALL. Single or in small cluster on small twigs on trees of *Q. alba* in late summer and fall. Diameter 10-15 mm., yellow or tinged with red, corky with a thin-walled free larval cell in center. Young galls appear in July, contain pupae in late fall, and adults emerge Oct. 20-Nov. 1.

87. *Disholcaspis globulus* (Fitch)

POINTED BULLET GALL. Similar but pointed at the apex, subclasping at base, often distorted by crowding and extending along the stem for several inches sometimes. Frequently on sprouts from stumps or on small trees in large numbers in the fall. On *Q. macrocarpa* and *bicolor.* Adults emerge Oct. 20-Nov. 10.

88. *Disholcaspis mamma* (Walsh)

BASSETT'S BULLET GALL. Broadest at the clasping sessile base and tapering gradually above, the apex often lopsided, 15-20 mm. high, the larval cell basal. Single or in crowded clusters on twigs of trees of *Q. bicolor* in fall. Adults emerge in early Oct.

89. *Disholcaspis bassetti* (Gill.)

PUBESCENT BULLET GALL. Clasping, conical, single or in small clusters on twigs or on scar tissue on main trunk or large limbs of trees of *Q. coccinea* and *imbricaria* in spring. Green and fleshy when fresh in May and covered with dense short white pubescence which weathers away after the galls mature. They turn brown and drop off in July. The larvae transform in the fall and the adults emerge some time in the spring probably.

90. *Callirhytis ventricosa* (Bass.)

BANDED BULLET GALL. Reddish-brown, globular, 7-10 mm. in diameter, in rows from vertical slits in the bark usually near top of vigorous sprouts from stumps of *Q. rubra, velutina* and *coccinea*, beginning to develop about Aug. 1 and dropping in late Sept. Adults emerge the next and the succeeding fall in late Sept. or early Oct.

91. *Dryocosmus imbricariae* (Ashm.)

Cluster of small barrel-shaped green or purplish galls bursting out of cracks in the bark of 2-3 year old twigs, the blunt galls sticking out in all directions for a distance of an inch or two along the twig. Each is 3 mm. long by 2 mm. in diameter, longitudinally grooved and when growing secretes honeydew from a gland in the truncate and depressed distal end. On *Q. rubra, velutina* and *coccinea*. They begin to develop in late May or early June and unless attacked by guest flies drop off early in July. Adults probably emerge in early spring. Attacked by guest flies the gall fails to drop, continues to grow, becomes woody and covered with normal bark and persists for years.

92. *Callirhytis gemmaria* (Ashm.)

Gall unknown but probably a bud or stem gall. A fly of this species was taken at Evanston, Ill., on April 9, 1910 ovipositing in bud of *Q. alba*.

93. *Bassettia gemmae* Ashm.

F. Leaf galls.

1. Gall an integral part of the tissue of the leaf (a thickening of vein or parenchyma or prolongation of a vein) and detachable only by tearing the tissue of the leaf, including here the hollow galls, those with a free-rolling

cell inside and the oak apples with a central cell supported by radiating fibers.

a. Oak apples. Spherical galls containing a central larval cell supported from the thin outer wall by fine radiating fibers or by a spongy network.

LARGE SPONGY OAK APPLE. Galls appear with the leaves in spring, becoming 40 mm. in diameter, green until full grown early in May, turning brown about the time the flies, males and females, emerge the latter half of June. On *Q. velutina*.

94. *Amphibolips spongifica* (O S)

Similar but the adults, all females, emerge in Nov. Probably an alternating generation of the above but the life history needs further study.

95. *Amphibolips confluentus* (Harris)

LARGER EMPTY OAK APPLE. Green with scattered purplish spots, 18-32 mm. in diameter, produced singly on under side of the leaf of *Q. rubra*. Adults emerged June 11, June 25, and July 6 in different seasons.

96. *Amphibolips inanis* (O S)

SMALLER OAK APPLE. Diameter 14 mm., a third of the sphere projecting from the upper surface of the leaf, the rest on under side, seldom more than one on a leaf, green, not spotted. On *Q. rubra* in May and June, the adults emerging early in July.

97. *Andricus singularis* (Bass.)

Similar but smaller, diameter about 8 mm., on *Q. coccinea* in June. Adults emerged July 8-15.

98. *Andricus osten sackenii* (Bass.)

b. Midrib or petiole swellings.

OAK PETIOLE GALL. Somewhat globular, conical above with a depression at apex, hard, green, polythalamous, the larval cells radiating out from the center. On the petiole or basal part of midrib, usually several in close proximity on the tree. In May and June, the adults emerging in late June. On *Q. alba, bicolor* and *macrocarpa*.

99. *Andricus petiolicola* (Bass.)

Abrupt smooth midrib swelling on lower side of leaf on basal half, 25 mm. long by 12 mm. wide, green, fleshy,

polythalamous, appearing in June the flies said to emerge in autumn or the next spring. On *Q. velutina, coccinea* and *imbricaria.*

100. *Callirhytis pigra* (Bass.)

Englargement of petiole and basal part of midrib, green, smooth, polythalamous, appearing in June, 20 mm. long by 13 mm. in diameter, the adults emerging during July. On *Q. rubra.*

101. *Callirhytis tumifica* (O S)

Smooth fusiform swelling along midrib of *Q. macrocarpa* in spring. Green, fleshy, polythalamous, the adults emerging about June 20.

102. *Callirhytis flavipes* (Gill.)

Slight local thickening of midrib on leaf of *Q. bicolor* with a rosette of leafy bracts both above and below. Green, fleshy, containing 1-6 cells, only one on a leaf, usually on the basal third, first appearing in May when the leaves are about one-third grown. Adults emerge in late June.

103. *Andricus foliosus* Weld

NOXIOUS OAK GALL. Fleshy smooth green swellings of midrib on under side causing the leaves to curl. Developing with the leaves in early spring, full grown during June, adults emerging June 12-July 3. On *Q. bicolor.* See 78.

104. sex. gen. of *Neuroterus noxiosus* (Bass.)

Swollen base of the petiole of *Q. imbricaria,* 6 mm. long by 2 mm. in diameter, remaining attached to the twig during the winter.

105. *Undetermined species*

c. Woolly galls of small size on under side of leaves of *Q. bicolor* and *macrocarpa* in large numbers in the fall, showing on the upper side only as smooth shining blisters. Often deforming all the leaves near the top of thrifty shoots. Adults emerge the next spring about April 15.

106. *Neuroterus floccosus* (Bass.)

(For detachable woolly galls on leaves see 2 b on p—)

d. Prolongations of veins beyond the margin of the leaf.

Gall fusiform, green, long-stalked, total length 15 mm., no free cell inside.

On *Q. alba* and *bicolor* in May. Adults emerged June 10-23.

107. *Andricus chinquapin* (Fitch)

Similar in appearance but has a separate larval cell inside (not free-rolling for it fills the cavity). On *Q. coccinea* in May. Adults emerge the last of June.

108. *Diplolepis pedunculata* (Bass.)

e. Galls with a free-rolling larval cell inside.

Globular, 10-12 mm. in diameter, wall thick, succulent, green with opaque white spots. On *Q. rubra* and *velutina* as leaves develop in early spring. Occasional on the staminate flower axis. Adults emerge during the first two weeks in June.

109. *Diplolepis palustris* (O S)

Hemispherical, slightly elongated, sessile by its flat face on the lower side of leaf of *Q. rubra* in spring. Greatest diameter 6 mm., wall very thin, green, veiny and translucent. Flies emerge about the last of May.

110. *Diplolepis cinereae* (Ashm.)

Elongated, blister-like, at edge of leaf, the conical tip prolonged on upper side of leaf into a sharp point, the walls very thin, green, veiny and translucent. In May on *Q. rubra, velutina* and *coccinea.* The flies emerge early in June.

111. *Diplolepis notha* (O S)

f. Deformed and much reduced leaves in early spring as buds open.

Cluster of thickened petioles without leaf blades, each about 5 mm. long and containing a dozen or so rounded cells. Slightly pubescent and pinkish. On *Q. alba* as buds open in the spring. Adults emerge the last of May.

112. *Neuroterus minutus* (Bass.)

Swollen leaf petioles and dwarfed and deformed leaves of *Q. macrocarpa* in May. Adults are said to emerge in May or June.

113. *Neuroterus vernus* Gill.

g. Galls in the parenchyma of the leaf, projecting on one or both surfaces, one or many celled.

Galls 3 mm. or more in diameter, not confluent into masses, 1-3 celled at most.

Gall hollow, spherical, 3 mm. in diameter, projecting equally on both sides of the leaf, green, fleshy, cavity large, solitary on leaf. In May on *Q. alba*. Flies probably emerge about the middle of June.

114. *Andricus utriculus* (Bass.)

OAK WART GALL. Lenticular, projecting more on the lower side of leaf, usually several on a leaf. Each contains 2-3 larval cells supported by radiating fibers. On *Q. alba* and *bicolor* in June. Adults emerge about the middle of July. See 32.

115. sex. gen. of *Callirhytis futilis* (O S)

Lenticular, more prominent on lower side of leaf, the upper surface depressed, hard, lighter in color than the leaf, but one or two on a leaf, typically containing two cells. On *Q. rubra* in May. Adults probably emerge in early July.

116. *Callirhytis rugosa* (Ashm.)

Individual galls less than 3 mm. in diameter or else coalescing so as to form large thickened patches of hypertrophied leaf blade.

Confluent so as to form an abrupt thick swollen area from 10-30 mm. long and 7-11 mm. thick. Green, smooth, somewhat translucent, usually but one on a leaf, polythalamous. On *Q. alba* in May. Adults emerge during the first half of June.

117. *Neuroterus majalis* (Bass.)

Confluent or single, hard, not succulent, upper surface of patches papillose, many such warty patches on leaf. On *Q. rubra* in June. Adults emerge in late June.

118. *Callirhytis modesta* (O S)

Cells isolated, more prominent on upper surface, scarcely projecting below, elliptical in outline, 1 mm. long, very numerous on leaf, exit hole below. On *Q. bicolor* in June. Adults emerge the last of June.

119. *Neuroterus papillosus* Beut.

Cells separate, numerous, elliptical, 1-2 mm. long, showing on both sides of the leaf but more distinct on

upper. On *Q. alba* in June and similar galls in the fall. Flies emerge from the overwintering galls April 1-23.

120. *Neuroterus perminimus* Bass.

Cells separate but in more or less definite rows along the midrib or a main vein, more prominent on upper side, a faint papilla in center below, round in outline, about 1.5 mm. in diameter. Exit hole on the lower surface. On *Q. alba* in the fall.

121. *Undetermined species*

Cells lenticular, adjacent to a vein in rows, more conspicuous on lower side which is covered with sparse rosy hairs, the wall thinner above. In early spring when leaves are one-third grown on *Q. macrocarpa*. Adults emerged May 30.

122. *Neuroterus fugiens* Weld

2. All leaf galls, single or in clusters, which when mature are deciduous or are easily detachable without damage.

a. Acraspis galls. Stony hard, whitish, more or less spherical, with a reticulated rough and often spiny surface. On white oaks in the fall, dropping with the leaves, the adults all females, wingless and emerging in late fall.

SPINY OAK GALL. Globular, 5-15 mm. in diameter, on under surface of leaf on midrib of *Q. macrocarpa*. Yellowish-green, monothalamous, the surface tuberculate, each tubercle conical and prolonged into a long hair of same color as gall or often red. Solitary or in a small group. Flies emerge after Nov. 1.

123. *Acraspis villosa* Gill.

Ellipsoidal, 3 by 4 mm., scattered on lower or sometimes upper surface of leaf of *Q. macrocarpa*, often one or two dozen on a leaf. Surface rough with blunt tubercles but not spiny. Monothalamous. Adults emerge about the middle of Nov.

124. *Acraspis macrocarpae* Bass.

OAK PEA GALL. Spherical, 5-8 mm. in diameter, two-celled, on under side of leaf of *Q. alba* on a vein. Surface reticulated by fissures into polygonal areas each bearing a slight papilla, yellowish, often tinged with red on one side

when developing in June, turning brown in fall. Adults probably emerge in late Nov.

125. *Acraspis pezomachoides* (O S)

HEDGEHOG GALL. Two to five-celled, ellipsoidal, 8-15 mm. long, usually on upper side of leaf on midrib, often several in a row, the surface tuberculate and bearing conspicuous red hairs. On large trees of *Q. alba*, starting to develop in late June. The flies emerge about Nov. 1 just before the leaves fall and oviposit on the same tree in the buds of the terminal cluster. See 71.

126. agamic gen. of *Acraspis erinacei* (Beut.)

b. Woolly galls on leaf. Occur in autumn. Deciduous or dropping with leaves.

OAK WOOL GALL. White woolly mass, 5-25 mm. long, on midrib above or below, containing 2-10 brown seed-like cells attached at one end. Falls with the leaf. On *Q. alba*. Adults emerge the next spring in May.

127. *Andricus flocci* (Walsh)

OAK FLAKE GALL. Similar but somewhat smaller more fluffy woolly masses scattered in large numbers on the under side of the leaf of *Q. bicolor* and *macrocarpa* attached to veins. They drop with the leaf and the wool weathers away during the winter exposing the 1-12 brown elliptical cells lying parallel with the leaf surface. Adults emerge the next spring during the first half of April.

128. *Diplolepis ignota* (Bass.)

Hemispherical brownish woolly mass on midrib on under side of leaf of *Q. rubra* and *velutina*. Made up of a cluster of easily detached separate angular galls which drop to the ground in the fall in Oct. before the leaves, each covered with a dense coating of wool. They are then fleshy and apparently solid as the larval cavity is very minute. Adults emerge the second and third springs in April.

129. *Callirhytis lanata* (Gill.)

c. Midrib clusters on leaf, the individual galls not so densely pubescent as to obscure the outline. These galls all develop in the late summer and drop to the ground before the leaves fall in the autumn. At this time they are fleshy, cutting like cheese, and apparently solid as the larval cavity

is very minute. During the winter or several winters on the ground the thick nutritive layer is used up by the larva leaving but a shell.

Galls angular.

A globular cluster, 8-20 mm. in diameter, on under side of petiole at its junction with the leaf blade, consisting of a dozen or more reddish-brown galls, closely pressed together, tuberculate at the distal end, flattened at the sides, tapering to the point of attachment, dropping to the ground in late Sept. or Oct. before the leaves. On trees of *Q. alba*. The emergence of the files is in March or early April and distributed over a period of five or six years, none probably appearing until the second spring.

130. *Cynips weldi* Beut.

An elongated cluster, 20 mm. long by 10 mm. wide, on under side on basal half of leaf of *Q. bicolor*. About a dozen galls in the closely packed cluster, color light brown. They start to develop about Aug. 1 and begin to drop in late Sept. Adults issue the next spring in the latter half of April.

131. *Cynips nigricens* Gill.

Galls not angular.

Globular, tapering below into a short stalk for attachment. In an elongated mass 6-18 mm. long consisting of from a few to about 30 closely packed light brown galls on basal third of leaf on under side. Individual galls 4-6 mm. in diameter, the basal half rusty, distal half bare and smooth, dropping in Oct. On *Q. alba* and *macrocarpa*. Emergence is in late April but does not begin until the second spring and is distributed over at least three seasons.

132. *Cynips dimorphus* Beut.

Similar in size and shape but red in color, in an elongated less compact cluster on upper or lower side of large leaves on thrifty shoots of *Q. rubra*, dropping in Oct. Pubescent under lens. Adults emerged Apr. 22-May 11 the second spring and some hang over to emerge still later.

133. *Dryocosmus piperoides* (Bass.)

Similar in shape but smaller, 2-3 mm. in diameter, whitish, sparsely covered with sprawling hairs, dropping in

Oct. In loose elongated clusters of 2-12 galls on under side of the larger lower leaves on vigorous sprouts from stumps of *Q. alba*. Galls collected in Oct. 1914 gave adults in Nov. 1915 and some hang over to emerge a year later.

134. *Diplolepis capillata* Weld

BLACK OAK WHEAT. Individual galls about size and shape of a kernel of wheat with a fleshy knob at upper end, greenish, smooth, bare. When young concealed in the swelling midrib but later bursting out of a crack in a compact cluster of from a few to 40 galls often rupturing the leaf blade so as to be visible from above, dropping in Oct. On *Q. rubra* and *velutina*. Galls collected in Oct. 1916 gave adults Mar. 23-Apr. 22, 1918.

135. *Dryocosmus deciduus* (Beut.)

d. Galls of other sorts attached separately, one or many, on a leaf.

Galls 5 mm. or more in diameter.

OAK GRAPE GALL. Large, spherical, 12-18 mm. in diameter, greenish-white, translucent, attached to under side of leaf in May, resembling a white grape. Monothalamous, smooth, bare, succulent, sour, shriveling to a shapeless black mass after the adult emerges early in June. On *Q. rubra* and *coccinea*.

136. *Amphibolips nubilipennis* (Harris)

Spherical, 6-11 mm. in diameter, covered with short felt-like grayish pubescence, the central cell supported by a layer of short dark brown radiating fibers and the outer wall thick. Attached to veins on the under side of leaf, often several on a leaf, dropping in late Sept. or Oct. and then turning brown. On *Q. alba* and *macrocarpa*. From galls collected in Oct. 1916 some adults issued Nov. 23-Dec. 11, 1916, more Nov. 1-19, 1917, more Dec. 2, 1919, all females and wingless.

137. *Philonix nigra* (Gill.)

Galls less than 5 mm. in diameter.

Spherical with a fleshy protuberance at the apex, 3-4 mm. in diameter, smooth, bare, greenish or tinged with red, bursting out of a crack in the side of midrib or main vein on under side of leaf in the fall, dropping before the leaf,

but few on a leaf. Adults emerge the second or third seasons in June or July. On *Q. rubra, coccinea* and *velutina.*

138. *Dryocosmus rileyi* (Ashm.)

Spherical or slightly ellipsoidal, not depressed, 3 mm. in diameter, smooth, bare, yellowish-green or tinged with red. On upper or lower side of leaves of *Q. rubra,* dropping before the leaves in the fall. From galls collected in Oct. 1916 adults emerged Mar. 13-Apr. 6, 1918.

139. *Zopheroteras sphaerula* Weld

Spherical but depressed, pure white, bare, 3-4 mm. in diameter. On under side of leaf of *Q. alba* in the fall, dropping before the leaf. Adult probably emerges the second spring.

140. *Biorhiza rubina* Gill.

Similar, depressed, pure white, 4 mm. in diameter on under side of leaf of *Q. coccinea* in fall, dropping in Oct.

141. *Undetermined species*

WHITE OAK SPANGLE GALL. Button-shaped, 3-4.5 mm. in diameter, with a heavy rounded ring of tissue on under side between pedicel and rim, concave above with a slight nipple in center, covered with a whitish bloom. In large number on under side of leaves of *Q. alba,* dropping in the fall. The flies emerge in late March the second spring.

142. *Xystoteras poculum* Weld

SPANGLE GALL. Concave above with no papilla in center, convex below without ring-like ridge, covered with whitish bloom, 3 mm. in diameter. On *Q. bicolor* and *macrocarpa* in August. Not reared.

143. *Undetermined species*

JUMPING NEUROTERUS GALL. Small ellipsoidal galls in cup-like depressions on under side of leaf in large numbers, dropping in July or Aug. and then exhibiting the jumping movements for some time. Showing on upper surface of leaf as smooth convex elevations of a lighter color. Galls 1 mm. in length, truncate or saucer-shaped above with a papilla in center, light yellow in color. Adults emerge some time the next spring. On *Q. macrocarpa* and *bicolor.*

144. *Neuroterus saltarius* Weld

Globular, pure white, bare, smooth, 1.5 mm. in diameter, scattered on under side of leaf of *Q. alba* in the fall.

145. *Undetermined species*

Globular, red, finely pubescent with a scar at apex, 1 mm. in diameter, very numerous on under side of leaf of *Q. alba* in the fall.

146. *Undetermined species*

Galls on Oak Arranged by Hosts.

Quercus alba.

Root—	
Ellipsoidal, 5 mm., brown, on rootlets	30. Callirhytis elliptica Weld
Cells in thick bark	32. Agamic gen. of Callirhytis fultilis (O S)
Button-shaped, rugose, 10-5 mm.	36. Callirhytis badia (Bass.)
Potato-like, brown	37. Callirhytis maxima Weld
White fleshy cluster in May	38. Trigonaspis radicola (Ashm.)
Cluster of bullet galls	42. Disholcaspis globosa Weld
Acorn—	
Cells inside acorn	52. Undetermined species
Bud—	
Pea-like, mottled, in spring	58. Andricus pisiformis Beut.
Fleshy green or brown vesicle in spring	60. Neuroterus vesicula (Bass.)
Small, pointed, white, in spring	61. Diplolepis gemula (Bass.)
Small, pointed, brown, in fall	62. Callirhytis gemmiformis (Beut.)
Green, inside bud in fall	66. Callirhytis mamillaformis Weld
Blister on bud scale in spring	71. Sex. gen. of Acraspis erinacei (Beut.)
Stem—	
Oak potato gall	76-7. Sex. gen. and agamic gen. of Neuroterus batatus (Fitch)
Oak club gall	79. Callirhytis clavula (O S)
Oak seed gall	82. Callirhytis seminator (Harris)
Oak fig gall	83. Xanthoteras forticornis (Walsh)
Round bullet gall	87. Disholcaspis globulus (Fitch)
Gall unknown—probably bud or stem	93. Bassettia gemmae Ashm.
Leaf—	
Oak petiole gall	99. Andricus petiolicola (Bass.)
On prolonged vein	107. Andricus chinquapin (Fitch)
Dwarfed leaves in early spring	112. Neuroterus minutus (Bass.)
Hollow, green, spherical, 3 mm.	114. Andricus utriculus (Bass.)
Oak wart gall	115. Sex. gen. of Callirhytis futilis (O S)
Succulent thickened patch of blade	117. Neuroterus majalis (Bass.)

QUERCUS ALBA—(Concluded.)

Elliptical cells in parenchyma, 1-2 mm.	120. Neuroterus perminimus Bass.
Round cells in blade in rows near vein	121. Undetermined species
Oak pea gall	125. Acraspis pezomachoides (O S)
Hedgehog gall	126. Agamic gen. of Acraspis erinacei (Beut.)
Oak wool gall	127. Andricus flocci (Walsh)
Cluster on petiole in fall	130. Cynips weldi Beut.
Midrib cluster globular brown galls	132. Cynips dimorphus Beut.
Midrib cluster globular whitish galls	134. Diplolepis capillata Weld
Globular, 6-11 mm., felt-like	137. Philonix nigra (Gill.)
Depressed, pure white, in fall	140. Biorhiza rubina Gill.
White oak spangle	142. Xystoteras poculum Weld
Globular, white, 1.5 mm.	145. Undetermined species
Globular, red and hairy, 1 mm.	146. Undetermined species

Quercus bicolor.

Root—	
Ellipsoidal, brown, 5 mm., on rootlets	29. Callirhytis ellipsoida Weld
Button-shaped, rugose, 10-5 mm.	36. Callirhytis badia (Bass.)
Potato-like, brown	37. Callirhytis maxima Weld
Acorn—	
Fimbriate cup gall	44. Andricus incertus Bass.
Cell in cup under acorn	45. Undescribed species
Cells inside acorn	51. Callirhytis lapillula Weld
Bud—	
Pea-like, mottled, in spring	58. Andricus pisiformis Beut.
Gray, spherical, 4 mm., in fall	59. Andricus deciduatus Weld
Fleshy green or brown vesicle in spring	60. Neuroterus vesicula (Bass.)
Small, pointed, white, in spring	61. Diplolepis gemula (Bass.)
Smooth, among leafy bracts	65. Callirhytis flavohirta (Beut.)
Green, inside bud, in fall	67. Undetermined species
Stem—	
Cells under leaf scar	72. Neuroterus escharensis Weld
Noxious oak gall	78. Agamic gen. of Neuroterus noxiosus (Bass.)
Slight enlargement of new growth	81. Neuroterus distortus Bass.
Pine-cone oak gall	84. Cynips strobilana O S
Pointed bullet gall	88. Disholcaspis mamma (Walsh)
Bassett's bullet gall, conical	89. Disholcaspis bassetti (Gill.)
Leaf—	
Oak petiole gall	99. Andricus petiolicola (Bass.)
Rosette of bracts on leaf	103. Andricus foliosus Weld
Midrib swellings in spring	104. Sex. gen. of Neuroterus noxiosus (Bass.)
Small, woolly, numerous, in fall	106. Neuroterus floccosus (Bass.)
On prolonged vein	107. Andricus chinquapin (Fitch)
Oak wart gall	115. Sex. gen. of Callirhytis futilis (O S)
Elliptical cells in parenchyma	119. Neuroterus papillosus Beut.

QUERCUS BICOLOR—(Concluded.)

Oak flake gall, woolly	128. Diplolepis ignota (Bass.)
Midrib cluster in fall	131. Cynips nigricens Gill.
Spangle galls	143. Undetermined species
Jumping Neuroterus gall	144. Neuroterus saltarius Weld

Quercus macrocarpa.

Root—	
Cells in thick bark	33. Compsodryoxenus illinoisensis Weld
Button-shaped, rugose, 10-5 mm.	36. Callirhytis badia (Bass.)
Potato-like, brown	37. Callirhytis maxima Weld
Bud—	
Pea-like, mottled, in spring	58. Andricus pisiformis Beut.
Fleshy green or brown vesicle in spring	60. Neuroterus vesicula (Bass.)
Small, pointed, white, in spring	61. Diplolepis gemula (Bass.)
Smooth, among leafy bracts	65. Callirhytis flavohirta (Beut.)
Green gall inside bud in fall	67. Undetermined species
Stem—	
Pine-cone oak gall	84. Cynips strobilana O S
Pointed bullet gall	88. Disholcaspis mamma (Walsh)
Leaf—	
Oak petiole gall	99. Andricus petiolicola (Bass.)
Midrib swelling	102. Callirhytis flavipes (Gill.)
Small, woolly, numerous, in fall	106. Neuroterus floccosus (Bass.)
Dwarfed leaves in spring	113. Neuroterus vernus Gill.
Cells along veins in early spring	122. Neuroterus fugiens Weld
Spiny oak gall	123. Acraspis villosa Gill.
Ellipsoidal Acraspis gall	124. Acraspis macrocarpae Bass.
Oak flake gall, woolly	128. Diplolepis ignota (Bass.)
Midrib cluster of globular brown galls	132. Cynips dimorphus Beut.
Globular, 6-11 mm., felt-like	137. Philonix nigra (Gill.)
Spangle galls	143. Undetermined species
Jumping Neuroterus gall	144. Neuroterus saltarius Weld

Quercus rubra.

Root—	
Globular, brown, bark thin	31. Eumayria floridana Ashm.
Local swelling in bark	34. Callirhytis rubida Weld
Cluster small oval galls	39. Callirhytis enigma Weld
Cluster wedge-shaped galls	40. Dryocosmus favus Beut.
Onion-shaped, in group	41. Biorhiza caepuliformis (Beut.)
Acorn—	
Acorn plum gall	43. Amphibolips prunus (Walsh)
Acorn pip gall	46. Agamic gen. of Callirhytis operator (O S)
Green, globular, 3-4 mm., in fall	49. Undescribed species
Stony mass inside acorn	50. Callirhytis fructuosa Weld
Flower—	
Woolly white mass	53. Sex. gen. of Callirhytis operator (O S)
Like green peas	54. Callirhytis pulchra (Bass.)

QUERCUS RUBRA—(Concluded.)

Bud—	
Large, spotted, in axils, in fall	55. Amphibolips cookii Gill.
Fusiform, long-stalked, ribbed	57. Callirhytis gallaestriatae Weld
Green, inside bud in fall	68. Undetermined species
Stem—	
Horned knot gall	74. Callirhytis cornigera (O S)
Oak knot gall	75. Callirhytis punctata (Bass.)
Banded bullet gall	91. Dryocosmus imbricariae (Ashm.)
Cluster small ribbed galls in spring	92. Callirhytis gemmaria (Ashm.)
Leaf—	
Larger empty oak apple	96. Amphibolips inanis (O S)
Smaller empty oak apple	97. Andricus singularis (Bass.)
Midrib swelling	101. Callirhytis tumifica (O S)
Spherical, 10-2 mm., free-rolling cell	109. Diplolepis palustris (O S)
Hemispherical sessile blister	110. Diplolepis cinereae (Ashm.)
Elongated, pointed blister at edge	111. Diplolepis notha (O S)
Hard, lenticular, two-celled	116. Callirhytis rugosa (Ashm.)
Papillose patches on leaf	118. Callirhytis modesta (O S)
Woolly mass on midrib	129. Callirhytis lanata (Gill.)
Midrib cluster globular red galls	133. Dryocosmus piperoides (Bass.)
Midrib cluster, green, like wheat	135. Dryocosmus deciduus (Beut.)
Oak grape gall	136. Amphibolips nubilipennis (Harris)
Globular with fleshy knob	138. Dryocosmus rileyi (Ashm.)
Rosy sphere, 3 mm., in fall	139. Zopheroteras sphaerula Weld

Quercus coccinea.

Root—	
Globular, brown, bark thin	31. Eumayria floridana Ashm.
Local swelling in bark	34. Callirhytis rubida Weld
Local swelling in bark	35. Callirhytis marginata Weld
Cluster wedge-shaped galls	40. Dryocosmus favus Beut.
Acorn—	
Acorn plum gall	43. Amphibolips prunus (Walsh)
Pip gall in spring, honeydew	47. Callirhytis balanosa Weld
Stony mass inside acorn	50. Callirhytis fructuosa Weld
Flower—	
Woolly white mass	53. Sex. gen. of Callirhytis operator (O S)
Like green peas	54. Callirhytis pulchra (Bass.)
Bud—	
Cluster small greenish galls in spring	63. Callirhytis rugulosa (Beut.)
Globular, inside bud in spring	69. Undetermined species
Globular, under trees in spring	70. Undetermined species
Stem—	
Cells in twig—no gall	73. Bassettia ceropteroides (Bass.)
Oak knot gall	75. Callirhytis punctata (Bass.)
Terminal swelling of new growth	80. Callirhytis scitula (Bass.)

QUERCUS COCCINEA—(Concluded.)

Cluster fig-shaped galls in spring	85. Andricus formosus (Bass.)
Pubescent bullet in spring	90. Callirhytis ventricosa (Bass.)
Banded bullet gall	91. Dryocosmus imbricariae (Ashm.)
Cluster small ribbed galls in spring	92. Callirhytis gemmaria (Ashm.)
Leaf—	
Small oak apple, 8 mm.	98. Andricus osten sackenii (Bass.)
Midrib swelling	100. Callirhytis pigra (Bass.)
On prolonged vein	108. Diplolepis pedunculata (Bass.)
Elongated, pointed blister at edge	111. Diplolepis notha (O S)
Oak grape gall	136. Amphibolips nubilipennis (Harris)
Globular with fleshy knob	138. Dryocosmus rileyi (Ashm.)
Depressed, white, in fall	141. Undetermined species

Quercus velutina.

Root—	
Onion-shaped, in group	41. Biorhiza caepuliformis (Beut.)
Acorn—	
Acorn plum gall	43. Amphibolips prunus (Walsh)
Pip gall on young acorn in fall	48. Callirhytis balanoides (Weld)
Green, globular, 3-4 mm., in fall	49. Undescribed species
Flower—	
Woolly white mass	53. Sex. gen. of Callirhytis operator (O S)
Bud—	
Melon-shaped, 4 mm., in spring	64. Undescribed species
Stem—	
Oak knot gall	75. Callirhytis punctata (Bass.)
Banded bullet gall	91. Dryocosmus imbricariae (Ashm.)
Cluster small ribbed gall in spring	92. Callirhytis gemmaria (Ashm.)
Leaf—	
Large spongy oak apple, adults in June	94. Amphibolips spongifica (O S)
Large spongy oak apple, adults in November	95. Amphibolips confluentus (Harris)
Midrib swelling	100. Callirhytis pigra (Bass.)
Spherical, 10-2 mm., free-rolling cell	109. Diplolepis palustris (O S)
Elongated, pointed blister at edge	111. Diplolepis notha (O S)
Woolly mass on midrib	129. Callirhytis lanata (Gill.)
Midrib cluster, green, like wheat	135. Dryocosmus deciduus (Beut.)
Globular with fleshy knob	138. Dryocosmus rileyi (Ashm.)

Quercus imbricaria.

Flower—	
Woolly white mass	53. Sex. gen. of Callirhytis operator (O S)
Bud—	
Cylindrical, in spring	56. Amphibolips ellipsoidalis Weld
Stem—	
Seed-like, in cracks in bark in fall	86. Andricus excavatus Ashm.
Pubescent bullet in spring	90. Callirhytis ventricosa (Bass.)
Leaf—	
Midrib swelling	100. Callirhytis pigra (Bass.)
Swollen petiole	105. Undetermined species

Quercus palustris.

Bud—	
Cylindrical, in spring	56. Amphibolips ellipsoidalis Weld

SUMMARY

Galls on plants other than oak		28
Galls on oak		
Root galls	14	
Acorn galls	10	
Flower galls	2	
Bud galls	17	
Stem galls	22	
Leaf galls	53	118
Total numbered galls in key		146
Undetermined	14	
Alternating generations	5	
		19
Total number of determined species in the Chicago area		127
On plants other than oak	28	
On oak	99	

PAPERS IN CHEMISTRY AND PHYSICS SECTION, JOLIET.

THE FLUORESCENCE MICROSCOPE.

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White light as we all know is composed of a mixture of color ranging from violet through indigo, blue, green, yellow, orange to red, the violet waves being the shorter, and the red the longer. When white light is passed through a prism it is broken up into these component colors and the result is known as the visible spectrum. By suitable means, there can be shown to exist at each end of the spectrum other wave lengths known as ultra violet if shorter than 3800 au, infra red if longer than 7600 au. These can be rendered visible by the power possessed by certain substances to convert these invisible wave lengths into visible ones. If the invisible infra red rays are focused by means of a suitable condenser on a piece of blackened platinum the platinum soon becomes heated to redness and emits light. This phenomenon is called calorescence or thermoluminescence and is due to the conversion of the long invisible infra red rays into shorter and visible rays.

If we now turn our attention to the other end of the spectrum we will find there are a number of substances having the property of converting the short invisible wave lengths into longer and visible ones but this time without heat being developed. Two phenomena will be observed here and will be called Fluorescence or Phosphorescence according to the way the substance under examination acts.

FLUORESCENCE—If the substance under examination emits light while under the influence of the ultra violet radiations but cease to do as soon as the exciting cause is removed the phenomenon is called Fluorescence.

PHOSPHORESCENCE—If on the other hand the emission of light by the radiated substance continues after the exciting cause is removed, it is called Phosphorescence.

Both these phenomena have been known to exist for many years but so far no satisfactory explanation for their existence has been given.

It is not the purpose of this paper to discuss the many theories relative to Phosphorescence and Fluorescence but

to act as an introduction of the Fluorescence Microscope. This apparatus consists of an arc lamp provided with a suitable condensing system, a series of filters and the microscope. The arc light is fitted with carbons so prepared to deliver a light rich in ultra violet. The condensing system is of quartz which is transparent to ultra violet—the filters, 2 in number, consist: one of 2 plates of quartz mounted in a suitable holder between which is a layer of 25% copper sulphate solution. This effectively removes the light waves at the red end of the spectrum. The second filter is two plates of UV glass separated by a layer of P. nitroso dimethyl anilin. The UV glass cuts out the yellow, orange, green and blue while the P. nitroso dimethyl anilin removes the violet. The stage below the microscope is equipped with a total reflecting prism of quartz and the microscope has an Abbe condenser of the same material. Quartz microscope slides are also used in these experiments.

The objectives and eyepiece of the microscope are of the ordinary glass system, quartz not being necessary here as we are dealing with visible radiations.

Since the visible light has been filtered out of the optical system it is necessary to devise some means of showing when illuminant on the optical system is in alignment. For this purpose we use a plate of uranium glass. This is placed in the place provided for it above the quartz prism and the beam of light adjusted until this uranium glass fluoresces brilliantly over this center area. It is then removed from the prism and placed above the Abbe condenser and at this point we should have a brilliant spot of light directly over the center of the condenser. This being accomplished, the microscope is ready for use. The substance to be examined is now mounted on the quartz slide and placed on the stage of the microscope in the usual manner and if it has any fluorescent properties it will become luminous, the light emitted being characteristic of the subject under examination.

The question now arises—since this light is visible to the naked eye, why use a microscope. This is for two reasons: One—Substances which are not usually considered fluorescent may contain minute quantities of substances which are fluorescent. These may be too small to be seen

with the naked eye but will be revealed by the microscope. Two—Many substances, particularly ore minerals are composed of a variety of chemical substances. When these are subjected to ultra violet radiation, the entire mass will fluoresce a single color, but examined under the microscope may be resolved into a number of different colors, each color coming from a different substance.

Minute quantities of impurities in apparently pure chemicals can be detected by this method.

Many of the algae show up beautifully when fluoresced, the chlorophyl appearing a brilliant red.

The number of substances fluorescing to ultra violet light is very great and are found in every line of research. Very little is actually known regarding the application of this phenomenon and much work will have to be done before any definite statements are made regarding the practical application of this type of microscope, or of the interpretation of the findings. However, this opens up a very wide field for research in almost every line of endeavor and gives great promise for the future.

THE SEPARATION OF OLD YTTERBIUM FROM GADOLINITE.

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In 1902, Dennis and Dales published a paper on Yttrium group separations (Journal of Amer. Chem. Soc. Vol. 24, No. 5, May, 1902). In this paper was presented one method which was shown to offer unusually rapid separation of the members of the yttrium group. Hardly enough material (Yttrium group oxides from sypilite) was at hand to permit of making a very extensive study of the most interesting fraction, which is the last one. The process referred to (reference page 430) is the one there called Fractionation with Ammonium Carbonate and dilute Acetic Acid. It is my purpose to show that nearly pure ytterbium oxide can be obtained from gadolinite by this method with comparatively few fractionations, and also to gain an idea of the approximate quantity of ytterbium oxide which can be thus obtained.

Preparation of Material.

The material used in these experiments was Gadolinite, partly because it was available and partly because it was the mineral from which Ytterbium was originally obtained. Twelve pounds of the solid dark Gadolinite was first crushed and ground to a fine powder in order to get it into a form in which it could be easily digested. The powdered material was put into large sized porcelain evaporating dishes, enough being taken to fill each dish half full. Enough Aqua Regia was then added to cover the powdered mass. The mineral was then stirred well and evaporated on air bath, nearly to dryness. Con. hydrochloric acid was added and the mass evaporated down again. The treatment with con. hydrochloric acid was repeated until no trace of chlorine was indicated when tested by the starch and potassium iodide paper method.

During the first evaporation to dryness a solid cement-like mass formed which was very slow in dissolving and was treated separately with Aqua Regia and afterwards

with Con. hydrochloric acid. Continued application of this method with heat resulted in its all being broken up.

When all the material was freed from chlorine the mass was covered with con. hydrochloric acid, heated about an hour, stirred, and the whole poured into a large cylinder. Enough water and hydrochloric acid (one-half each) was added to double the volume. This was all well stirred and allowed to stand several hours for the solid part to settle. The silica settled quickly, but the silt and greenish mass (probably iron silicate) settled very slowly and formed a distinct layer on the surface of the silica. The acid solution contained a part of the rare earths of the yttrium and cerium groups; also glucinum and iron and some other impurities.

After settling quite clear the acid solution was siphoned off and just neutralized with ammonium hydroxide. A permanent brownish precipitate showed when the solution was slightly alkaline. Just enough acid was added to dissolve this precipitate. Then 25cc excess of the acid was added for 5 liters of solution, which made about the correct per cent of acidity for precipitation of the earths present. This solution was then set away while other extractions were made on the same residue. About half of the rare earths present in the gadolinite ore were extracted by the first aqua regia treatment. The process of extraction was repeated six times with profit. When these extractions were completed and the resulting solutions made slightly acid as above, the cerium and yttrium groups of earths were precipitated by adding an excess of solid oxalic acid and stirring with air. The solution required about three hours of this treatment to get complete precipitation. The oxalate precipitates settled readily to the bottom.

The supernatant liquid was siphoned off from the above. This solution contained iron and glucinum as they do not form precipitates with oxalic acid in dilute acid solutions. If too much hydrochloric acid is added before treating with oxalic acid, some of the cerium and yttrium group oxalates may not precipitate completely, as some are slightly soluble in dilute acid solutions. To be sure that all of the cerium and yttrium oxalates were all precipitated the solution was partially neutralized with ammonium hydroxide and treated again with oxalic acid crystals. No glucinum

will precipitate as long as the solution is acid with oxalic acid or hydrochloric acid. Some cerium and yttrium groups of earths were recovered by this treatment. When all the cerium and yttrium earths were removed, the glucinum and iron were precipitated from the solution by adding an excess of ammonium hydroxide. This precipitate was saved on account of the glucinum which it contained. The remaining solution was discarded as it contained only ammonium salts and some impurities.

The white oxalates secured as described above were washed a number of times in large cylinders by siphonation with distilled water. They were finally washed in a Buchner funnel with distilled water using strong linen fibre filter papers.

The oxalates were removed on the filter paper to an air bath, heated at a temperature of 105 degrees C. or higher until thoroughly dry. This required several hours. A temperature of 140 degrees C. did no harm to the precipitate. Heat may be applied until the paper begins to char. Too great a temperature would partially convert the oxalates into oxides and make the mass hard to dissolve later.

The oxalates were then powdered very fine in a mortar and ignited in small quantities in a quartz evaporator. The powder must be stirred all the time in order to prevent the lower portion from becoming over-heated. A light gray color indicates that the oxalates have been converted into carbonates, which is the form desired. Too much heat will convert the carbonates to oxides, which because of the cerium present makes it hard to dissolve. On the other hand, if not heated enough, the oxalates will not be destroyed. If a small amount of oxalate precipitate is left over it will be destroyed later by nitric acid.

The carbonates of the earths secured as described above were then treated with concentrated nitric acid and hydrogen peroxide. One liter of concentrated nitric acid was put in a large porcelain evaporating dish, heat applied and the earths added as long as they would dissolve. (1.5 kgm of Carbonate for 1 liter of nitric acid.) About 50cc of hydrogen peroxide was added to put the last of it in solution. Several hours time with heat was required to dissolve the carbonates. The solution with a slight trace of sediment was then put into large cylinders and allowed to settle two

days. Some of the sediment dissolved in that time. The material left on the bottom of the cylinder then was mostly carbon and oxides that were difficultly soluble (probably mostly cerium di-oxide). This strong acid solution was filtered through a double filter in a Buchner funnel. The solution was then neutralized with ammonium hydroxide. Acid and alkali were added slowly to get the exact neutral point. The solution was stirred continuously with air to aid in getting this result. Two days' time was allowed for this treatment to be certain of the neutral point. When exactly neutral, the solution was subjected to the alkaline sulphate treatment for the removal of the cerium group. An excess of sulphate was added and stirred for two days to get complete reaction. Time seemed to be a factor in getting this reaction. One treatment with alkaline sulphate was not sufficient to remove all of the cerium group. In fact, seven treatments were necessary before the absorption spectra of old didymium disappeared. The alkaline sulphate used was mostly potassium sulphate, but some sodium sulphate was used. After each sulphate treatment the earths had to be precipitated and washed free from sulphate. The precipitation and washing of the hydroxides was tried, but was found to be too tedious. The precipitation of the earths as oxalates was found to be the most satisfactory. The oxalate precipitate was washed free from sulphate, filtered on a Buchner funnel and dried in an air bath. The oxalates were then powdered, roasted to carbonate and the carbonates dissolved in nitric acid. After the above described treatments the solution then left was supposed to contain only yttrium group elements.

Fractionations.

When the last treatment was finished the yttrium group earths were left dissolved in nitric acid. The earths were precipitated from this solution by ammonium hydroxide and washed. These hydroxides were dissolved in saturated ammonium carbonate solution. The high atomic weight material dissolves very readily. That of lower atomic weight dissolves more difficultly and cerium and didymium hydroxides if present remain largely undissolved. I found that the ammonium carbonate solution would dissolve more earths if it had some ammonia water added to it (1 to 10). This was doubtless due to the presence in the solution of

carbamate or other carbon compounds from the solid ammonium carbonate used. The best results were obtained by adding the earth hydroxides in small quantities to the ammonium carbonate solution and stirring until the solution was saturated. When the ammonium carbonate solution was poured onto the earth hydroxides a much larger quantity of ammonium carbonate was required to effect solution, as a sort of coating was formed over the mass of hydroxides which would not readily dissolve. The excess of earths remaining in each jar after the solution was saturated, was filtered off. This would not dissolve readily in ammonium carbonate so it was dissolved in nitric acid, reprecipitated with ammonia and then dissolved in fresh ammonium carbonate solution.

After all the earths were dissolved in saturated ammonium carbonate they were fractioned with acetic acid solution. First the ammonium carbonate solution of the earths was treated with concentrated acetic acid to destroy the excess of ammonium carbonate present. The acid had to be added slowly and the mixture stirred well on account of bubbling. The appearance of a very faint cloud indicated the end point. In working with a sample of the solution it was found necessary to give considerable time to this treatment because when the acid was added rapidly to a cloud a large precipitate would fall on standing several minutes. After bringing the whole solution to a faint cloud a sample of it was tried with different quantities of one-thirtieth strength acetic acid solution (1 acid to 29 water) to determine what proportion of this strength acid was necessary to obtain maximum precipitation. At this point Dennis and Dales used the amount of one-thirtieth acetic acid solution necessary each time to give maximum precipitation. This gave from 4 to 6 fractionations, but the last one, while the most interesting, was very small. In an effort to increase the amount of this last fraction without impairing the efficiency of the fractionation, I used a quantity of one-thirtieth strength acetic acid less than that required for maximum precipitation. In the first part of the work one-fifth the amount of one-thirtieth strength acetic acid necessary for maximum precipitation was used. This amount was estimated in the following way:

Example.

18 tubes—10 cc each (clouded as described above).
Added 1 cc of 1-30 acet. to 1st tube.
Added 2 cc of 1-30 acet. to 2nd tube.
Added 3 cc of 1-30 acet. to 3rd tube.
Added 4 cc of 1-30 acet. to 4th tube, etc.

I found the maximum precipitation in the 15th tube. Thus 15cc of one-thirtieth strength acetic acid in 10cc of sample gave maximum precipitation. I used one-fifth that amount or 3cc of one-thirtieth strength acetic acid for each 10cc of sample. This was added slowly to prevent too rapid bubbling. A granular precipitate slowly settled to the bottom forming the first fraction. This was filtered off. On trial it was found that this same amount of acetic acid would not produce a precipitate in the remaining solution, but that it was necessary to bring the solution to a cloud again. After determining the amount necessary then for maximum precipitation in the clouded solution, it was treated in the same way with one-fifth that amount. The precipitate thus formed was filtered off and was known as fraction number two.

The ammonium acetate then in the solution prevented further fractions from being properly extracted from this solution, because the earths are readily soluble in ammonium acetate. The remaining carbonate present was destroyed with nitric acid and the earths removed from the solution by precipitating with ammonium hydroxide.

The earth hydroxides were filtered in the Buchner filter and again dissolved in saturated ammonium carbonate solution. The ammonium carbonate solution was again brought to a faint cloud to destroy the excess of carbonate. Tests were then made as before to determine how much one-thirtieth strength acetic acid was necessary to give maximum precipitation. This time only one-tenth of the estimated amount was used. The precipitate thus obtained formed the third fraction. The fourth fraction was obtained from this solution using the same plan as used in getting fraction number two except that one-tenth the calculated amount of dilute acetic acid solution was used the same as in fraction number three.

The small amounts of earths then remaining in solution formed the last two fractions. The carbonate solution

in which they were dissolved was destroyed as before with nitric acid and the earths precipitated as hydroxides. The hydroxides were put into solution in ammonium carbonate and the fifth fraction extracted the same as the third. The earths remaining in solution then were taken as the sixth fraction. This was supposed to contain the most of the ytterbium, as the low atomic weight metals are supposed to precipitate first.

This series of fractions just described was known as Series 1. Three other series of fractionations were run upon different fractions of the first series in order to get out all the ytterbium possible. The second series consisted of six fractions. The material used for this series of fractionations was obtained by putting together the largest part of the earths obtained in fractions 1 and 2 of series 1. Only a small amount of each fraction was saved as a sample and for atomic weight determinations. Series 3 consisted of 4 fractions and was made from a combination of the fifth fraction of the first series and the sixth fraction of the second series. Series 4 consisted of six fractions and was made from a combination of the third and fourth fractions of the first series and the fourth and fifth fractions of the second series.

Atomic Weight.

The sulphate method was used in determining the atomic weight. The particular modification of this method that was used was the dissolving of the oxides in dilute hydrochloric acid and converting to sulphates by the addition of dilute sulphuric acid. The liquid was evaporated as far as possible on the water bath. Then the excess of sulphuric acid was driven off by heating the platinum crucible and contents in an asbestos nest in a large iron crucible.

Series 1—Fractionation

Fraction	Wt. Gm.	Color of Oxide	At. Wt.
1	550	strong buff	100.5
2	135	buff	100.2
3	85	mild buff	109.8
4	20	nearly white, rose tint	138.0
5	3.28 oxide	white, slight rose tint	153.0
6	3.65 oxide	white	173.5

The buff color is due to Terbium content. Its oxide is deep brown, but in small quantities gives buff.

Series 2—Fractionation

Made from a combination of 1st and 2nd fractions of Series 1.

Fraction	Wt. Gm.	Color of Oxide	At. Wt
1	300	very strong buff	99.1
2	105	strong buff	101.7
3	90	buff	104.1
4	35	slight buff	113.9
5	8	white, rose tint	114.6
6	3.42	white, slight rose	146.7

Series 3—Fractionation

Made from a combination of 5th fraction of 1st series and 6th fraction of 2nd series.

Fraction	Wt. Gm.	Color of Oxide.	At. Wt.
1	2 oxide	white, slight rose	130.1
2	1.5 oxide	white, slight rose	142.3
3	1.5 oxide	white, slight rose	154.6
4	1.6 oxide	white	163.2

Series 4—Fractionation

Made from a combination of fractions 3 and 4 of the first series, and fractions 5 and 6 of the second series.

Fraction	Wt. Gm.	Color of Oxide
1	60	Buff
2	50	Buff
3	25	Light Buff
4	10	Light Buff
5	1.5	Very light buff
6	1.0	White, slight rose

The sixth fraction in this series gave an atomic weight of 146.

The last fraction in each series was examined with the spark spectrum. Each fraction examined showed the presence of ytterbium. As would be expected, the last fraction of the first series gave the strongest test, showing nearly pure ytterbium.

Conclusion.

The research has shown that the method employed of fractioning yttrium group earths with dilute acetic acid in ammonium carbonate solution is a very satisfactory method. The last fraction of the first series gave an atomic weight of 173.5. When these experiments were finished this value was thought to be too high for pure ytterbium, but later

atomic weight determinations show the correct atomic weight of ytterbium to be 173.5, which is exactly the atomic weight secured for this fraction which is supposed to be the fraction containing the purest ytterbium. In the past, thousands of fractionations have been made in order to separate out a single rare earth element. By the process presented here, very pure ytterbium was evidently prepared from Gadolinite in six fractionations.

THE EVOLUTION OF THE INCANDESCENT LAMP.

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The year 1820 probably marks the first attempt at making an actual incandescent lamp. In that year De la Rue built a lamp consisting of a coil of platinum wire in a glass tube the ends of which were covered with brass caps and from which the air could be exhausted.

In 1840 Sir William Robert Grove made an experimental lamp by attaching the ends of a coil of platinum wire to copper wires, the lower parts of which, or those most distant from the platinum, were well varnished for insulation. The copper wires were fixed erect in a glass of distilled water and another cylindrical glass placed over them, so that its open mouth rested on the bottom of the former glass. This prevented draughts of air from cooling the incandescent platinum, and the small amount of oxygen in the tumbler reduced the amount of oxidation of the platinum that would otherwise occur. He lighted the auditorium of the Royal Society with these lamps during one of his lectures, the current being supplied by a large number of cells of his improved primary battery.

During the thirty odd years following Grove's demonstration, several experiments, of more or less significance, were made on incandescent lamps. In 1845, J. W. Starr, a young American, invented two lamps. One had a platinum strip the length of which could be adjusted to fit the strength of the battery used. The other consisted of a carbon rod operating in the vacuum above a column of mercury as in a barometer.

In 1859, Professor Moses G. Farmer of the Naval Training Station at Newport, Rhode Island, lighted the parlor of his home at Salem, Massachusetts, with strips of platinum operating in air. The platinum strips of these lamps were narrowed at their terminals to increase the resistance of these points so that the strips were uniformly incandescent throughout their entire lengths. The terminals conducted the heat away from the burner tending to lower the temperature of the platinum at the points of

contact which was offset by the greater resistance at these points.

In the year 1872, a Russian scientist by the name of Lodyguine made a lamp consisting of a "V" shaped piece of graphite operating in nitrogen gas. He lighted the navy dockyard at St. Petersburg with two hundred of these lamps.

Kosloff, another Russian scientist, in 1875, made a lamp having several graphite rods for burners which operated in nitrogen gas. They were so arranged that one rod operated at a time, and when it burned out, another was automatically put in circuit. During the same year, Konn made a similar lamp having the graphite rods operating in a vacuum.

Up to this time the development of the incandescent lamp was more of an experimental nature than commercial. The arc lamp had come to take its place in the field of commercial artificial lighting.

While the arc lamp was being commercially established, and though proving to be adaptable to various forms of industrial lighting, it was at once seen that it was too large a unit for household use. Of the many inventors who attacked the problem of making a smaller unit, the first of prominence was William Edward Sawyer, assisted by Albon Man.

In 1877, Sawyer developed his "electric candle" consisting of a rod of preferably white refractory substance, such as clays, lime, etc., around which was coiled a platinum wire or wires. An electric current heated the wires to incandescence. The heat of the incandescent platinum wires was transferred to the refractory substance, causing the latter to glow with a soft light.

Sawyer early realized that platinum was too costly a substance and the results too unsatisfactory to permit it to ever be developed for practical commercial use. Sawyer abandoned the idea in favor of carbon. In the year 1878, Sawyer made several lamps embodying a carbon burner operating in an atmosphere of nitrogen gas.

In February, 1878, Sawyer made a lamp consisting of a piece of gas-retort carbon heated to incandescence by an electric current in a Florence flask, through which a stream of ordinary illuminating gas was kept flowing. This atmos-

phere was employed because it contained no oxygen to unite with and destroy the carbon while in an incandescent state.

An experiment made on March 6, 1878, in which paper was accidentally carbonized while being used as a convenient receptacle for a fine line of powdered graphite, first suggested that this material might perhaps be made into carbon useful in incandescent electric lighting.

Sawyer and Man spent considerable time experimenting on the carbonization of paper. One time Man took a piece of paper embedded in graphite in a closed vessel and carbonized it by subjecting it to a high temperature in his kitchen range. He then took the carbon structure, all that was left of the paper, and placed it in a flask charged with hydro-carbon gas and brought it to incandescence by passing an electric current through it. The latter part of this experiment, that of heating to incandescence in an atmosphere of hydro-carbon gas the filament of carbonized paper, developed into a very important process in the manufacture of carbon lamps. This process was called "flashing," "re-carbonizing" or "treating" and was later developed to a very high degree of perfection. Before treating, all filaments, those of Sawyer's and Man's carbonized paper filaments and the later carbonized cellulose filament, varied more or less in diameter. At the points of smaller diameter the resistance was greater, and therefore the heat was greater, thus augmenting disintegration. In the process of treating, the filament was suspended in an atmosphere of hydro-carbon vapor, which was at a considerably reduced pressure and brought to incandescence by passing an electric current through it. The hot filament decomposed the vapor, depositing graphite on the filament. Due to the increased heat at the thinner portions of the filament, those portions were built up more rapidly than the thicker portions, until in a few seconds the entire filament was of a practically uniform thickness. This treating process considerably lengthened the life of the filament by giving it a uniform resistance throughout its length. Perhaps the most valuable and important result of the hydro-carbon treatment consisted in its capacity for giving to the filament surface the highest possible power of luminous radiation.

After spending considerable time experimenting with carbonized paper, wood and other fibrous materials, Sawyer

and Man, had by June, 1878, constructed incandescent lamps capable of burning for many days. One lamp was run for many weeks at a luminosity of from one hundred to two hundred candle-power.

Thomas A. Edison began experimenting with the incandescent lamp in the Spring of 1878. Edison first made many experiments to confirm the failure of Sawyer and Man and others. Convinced of the seeming impossibility of carbon, he turned his attention to platinum as a light giving element. After considerable experimenting, he made a lamp having a long coil of fine platinum wire mounted on pipe clay. This was put in a one-piece all glass globe from which the air had been exhausted to effect a high degree of vacuum.

This lamp was expensive to make and to renew. By this time Edison was beginning to realize the impracticability of using platinum for the burner and, as had his predecessors already deemed it expedient to do, was turning his attention to carbon. After several trials he finally was able to carbonize a piece of ordinary sewing thread, with which he made a carbon filament vacuum lamp. On October 21, 1879, current was turned into the lamp and it lasted 45 hours before it failed. A patent was granted on this lamp January 27, 1880. All incandescent lamps made today embody the basic features of this lamp. The efficiency of the lamp was about 1.4 lumens per watt. Edison immediately began searching for the best material for a filament and soon found that carbonized paper gave several hundred hours life. The first commercial Edison incandescent lamps had carbonized paper filaments. The first commercially successful installation of the Edison incandescent lamps was made on the steamship Columbia, which started May 2, 1880, on a voyage around Cape Horn to San Francisco, California.

The carbonized paper filaments were quite fragile. Carbonized bamboo was found to be not only sturdy but it made an even better filament than carbonized paper. Carbonized bamboo filament lamps were introduced early in 1880. The filament material for this lamp was selected from about 6000 specimens gathered from many parts of the world. The average life of these lamps was 792 hours, though occasionally some would burn as long as 3000 hours.

The efficiency of these lamps was about 1.6 lumens per watt.

The year 1886 marked the introduction of the squirted cellulose filament lamp. The filaments of these lamps were made according to what was known as Swan's Squirting Process. By this process a perfectly structureless and uniform thread was produced by pressing a viscid solution of nitro-cellulose or of cellulose through glass jets into a coagulating liquid. The thread as it emerged from the jet had sufficient tenacity to maintain continuity until it was deposited in a coil on the bottom of the vessel containing the coagulating liquid which was usually alcohol of a certain strength. The coil was transferred to washing vessels and treated until nothing remained but a beautifully smooth and transparent length of pure and structureless cellulose thread. This cellulose thread was dried under tension, passed through polishing dies and carbonized. The squirted cellulose filament lamps not only had a longer useful life than the former carbon lamps, but were much more uniform in quality. The efficiency was increased to 2.5 lumens per watt.

In 1893 the filaments of the carbonized bamboo lamps were "treated" by the hydro-carbon process developed by Sawyer and Man.

In 1896 the squirted cellulose filaments were also "treated." By this time lamps were being made in relatively large quantities. The treated cellulose filament lamps had a longer life and their efficiency was about 3.3 lumens per watt.

Dr. Auer Von Welsbach, the German scientist who had produced the Welsbach gas mantle, invented an incandescent lamp having a filament of the metal osmium. It was commercially introduced in Europe in 1905 and a few were sold, but it was never marketed in this country. It had an average efficiency of 5 lumens per watt. Osmium is very rare and difficult to obtain. It is also very brittle, so that the lamps were extremely fragile.

In 1905 the Gem Metalized Filament Lamp was put on the market. The filament of this lamp was carbon which had been so changed by subjecting it to the intense heat of an electric furnace that it more nearly resembled a metal in its resistance characteristics; hence the term "Metalized

Filament." Like the metals, the filament of the Gem lamp had a positive temperature co-efficient, causing an increase in resistance with increased temperature. This feature gave the lamp in a measure, the self regulating quality of the high efficiency metallic filament lamps that were later developed. The Gem lamp could be burned on a slightly fluctuating voltage with comparatively small variation in light output. The efficiency of these lamps was 4 lumens per watt.

Von Bolton produced the tantalum lamp which was put on the market in this Country in 1906. The metal tantalum had been known to science for about a century. After considerable experimenting, he finally obtained some of the pure metal and found it to be ductile so that it could be drawn out into a wire. It has a low specific resistance so the filament had to be much longer and thinner than the carbon filament. It had a good maintenance of candlepower during its life, having an average efficiency of about 5 lumens per watt. The life on alternating current was considerably shorter than on direct current, due to more rapid crystallization of the filament.

The first tungsten lamp was placed on the American market in 1907. It had a pressed tungsten filament, produced by making a paste of tungsten powder and a carbonaceous material and squirting the paste into a thread through diamond dies. The pressed tungsten filaments were quite fragile. These lamps had an efficiency of 8 lumens per watt.

After several years of experimenting, Dr. W. D. Cooldige of the Research Laboratories of the General Electric Company, made the remarkable discovery that under proper conditions of working, the crystals of the metal tungsten were drawn out into fibres and in that state the tungsten filament was no longer brittle but ductile. His first success was obtained by repeatedly drawing a tungsten filament under careful heat conditions through heated dies. On the basis of this discovery a commercial process was developed and drawn tungsten filament lamps were put on the market in 1911.

This improvement brought the efficiency of vacuum lamps to about 10 lumens per watt.

Soon after the introduction of the tungsten filament vacuum lamp, chemicals were put in these lamps to improve their maintenance of candlepower during their life. "Getters" was the name given to these chemicals. One of the getters used had thallic chloride as a base. This salt dissociated with heat, releasing chlorine gas which combined with the tungsten as it vaporized from the filament while the lamp burned. The otherwise black deposit of tungsten on the inside walls of the bulb was converted into tungsten chloride which is light in color, thus cutting off less light from the filament during the life of the lamp. Many improvements have been made in the use of getters. By the method now in use, the getter is put directly on the filament and when the lamp is lighted for the first time, the getter vaporizes, condensing on the inside walls of the bulbs, coating them with an invisible layer ready to take care of the vaporizing tungsten as it strikes the bulb. By the use of getters the mean efficiency of lamps throughout their life is improved by about 10 per cent.

The higher the temperature at which an incandescent lamp filament can be operated, the more efficient it becomes. The limit is reached when evaporation of the tungsten becomes so rapid as to appreciably shorten the life of the lamp. If, therefore, the evaporating temperature can be slightly raised, the efficiency will be greatly improved. This was accomplished by Dr. Irving Langmuir by operating a tungsten filament in an inert gas, namely, nitrogen. This gas principle had been tried by Edison and others many years before but it was not successful with the straight filament on account of heat losses through the gas in the bulb. To overcome the excessive heat losses, the filament was coiled, thus presenting a smaller surface to the currents of gas and thereby reducing this loss. The gas-filled lamps were commercially introduced in 1913.

The first gas-filled lamps were the 750 and 1000 watt sizes. To offset the heat that is constantly being conducted away by the gas of these lamps, an increased amount of electrical energy is required. In the vacuum lamp, this heat loss is held to a minimum, the filament tending to stay hot on the principle of the vacuum bottle. This loss in a gas-filled lamp becomes relatively great in a filament of small diameter, as the surface in proportion to the volume

of the filament increases with decreasing diameter. Hence, there is a point where the gain in temperature is offset by the heat loss. Below this point the efficiency of the gas-filled lamp decreases. By the end of the year 1914, the smallest gas-filled lamp was the 200 watt size. However, in 1915, the use of nitrogen gas in the gas-filled lamps was discontinued and argon gas was used. Argon has a poorer heat conductivity than nitrogen, thereby reducing the heat loss of the lamp which becomes of increasing importance the lower the wattage of the lamp. The present day gas-filled lamps contain argon gas. It is now possible to make an efficient commercial lamp as low as 50 watts for 115 volt circuits. The present standard 1000 watt gas-filled lamp has an efficiency of 21 lumens per watt. The 1000 watt projection lamp has an efficiency of 26 lumens per watt.

STANDARDIZATION OF ACIDS WITH CARBONATES AND WITH BICARBONATES.

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The original purpose of the investigation was to compare the results of standardizing acids with carbonates and bicarbonates. Usually the instructions are to convert a good grade of the bicarbonate into carbonate and with the latter as primary standard titrate the acid against a known weight of it. The method is time-consuming and, in the hands of inexperienced students at least, is not always satisfactory. Any inaccuracy has been thought to be due to incomplete conversion of the bicarbonate during the heating. If the purity of the bicarbonate could be relied upon it would seem to be a better method to titrate directly with the bicarbonate. The reason for not doing so has probably been due to the belief that the purity of the bicarbonate could not be relied upon. It occurred to the author to compare the results in the normality of some acid by titrating it against a number of bicarbonates and the carbonates made from them. And since in the titration of carbonates they are first converted completely into bicarbonates, using phenolphthalein as indicator, when one-half the total volume is used it seemed desirable to observe whether the change in color of indicator occurred when one-half of the total volume was used. The results were so different from the theory that it seems desirable to include data on both points. In the titration of carbonates phenolphthalein was used in the first half and methyl orange in the second part. With bicarbonates only the latter indicator was used.

The preliminary work was carried out with a fairly good grade of sodium bicarbonate, and was titrated with sulphuric acid of nearly two normal. While the results were in the same direction as those obtained later with purer material and a more dilute acid it is felt that the possible errors are so great as to warrant their not being included in the published report. It was soon seen that it would be necessary to establish the normality of the acid to be used by some independent method. Consequently a solution of

hydrochloric acid of approximately two-tenths normal was prepared and its strength accurately determined as follows: Duplicate samples of silver nitrate, of high purity were precipitated with excess of hydrochloric acid and the weight of the silver chloride compared with that of the nitrate. The ratio, $AgNO_3$: AgCl in the duplicates was 1: .8434 and .84367. Theory for pure silver nitrate is .84377. A standard solution of this nitrate was then prepared and the solution titrated against a solution of sodium chloride made by dissolving 5.846 gms of very pure salt in a liter of solution. As a result of nine closely agreeing titrations the normality of the salt solution was found to be .1005 using two-tenths normal silver nitrate, and .10007 against one-tenth normal silver nitrate. The two-tenths normal silver solution, considering it to be exact within experimental error, was then titrated against the acid solution previously prepared, after neutralizing the acid with sodium hydroxide, using potassium chromate as indicator. The average of ten closely agreeing results gave a normality of .194 for the acid. With this acid and a sample of "certified" sodium bicarbonate, obtained especially for the purpose, the following work was carried out. At first, ordinary distilled water was used as solvent for the bicarbonate, the volume being indefinite but between 200 and 350 cc for each determination. Later the water was freshly boiled but not measured; and finally accurately measured volumes of the freshly distilled and cooled water were used and protected with sodium hydroxide from absorption of carbon dioxide. With each table the conditions are indicated. The bicarbonate was dried at 50° to 70° and tested for alkali reaction with phenolphthalein, (p. p below) giving negative results. In titrating the burette was filled to the zero mark for each

TABLE I.

ORDINARY DISTILLED WATER IN INDEFINITE VOLUMES.
Methyl orange (M. O.) used as indicator.

Exp. No.	Wt. of $NaHCO_3$	Vol. HCl M. O.	Wt. $NaHCO_3$ per cc HCl	Normality found
1	.5625	35.1	.0160256	.1908
2	.5733	35.7	.0160588	.1911
3	.4778	29.8	.0160335	.1909
4	.3905	24.33	.0160501	.1910
5	.2867	17.94	.0159816	.1902
6	.3962	24.6	.0161057	.1917
7	.3834	23.85	.0160755	.1913
8	.3371	20.95	.0160907	.1915
9	.3638	23.00	.0160130	.1906
Average of 9 results			.0160483	.1910

titration and nearly the same volume used in order to eliminate errors due to inexact calibration.

While these titrations were being carried out a quantity of the same bicarbonate was heated in a sand bath to 300 until constant weight was secured. 8.9597 gms. bicarbonate on heating two days lost 3.2980 gms. The theoretical loss for the pure carbonate is 3.3065 or .09 of one per cent more.

TABLE II.

TITRATION OF SODIUM CARBONATE MADE FROM THE BICARBONATE USED ABOVE. ORDINARY DISTILLED WATER, INDEFINITE VOLUMES.

Exp. No.	Wt. of Na_2CO_3	Vol. HCl P.P.	Vol. HCl M.O.	Ratio P.P:M.O.	Vol. HCl Total	Normality found	Average
1....	.2056	10.05	10.75	1:1.07	20.8	.1865	
2....	.2477	12.10	12.70	1:1.05	24.80	.1884	.....
3....	.2695	13.40	13.60	1:1.01	27.00	.1883	.1877
		Freshly boiled, distilled water, indefinite volumes.					
4....	.3085	14.95	15.85	1:1.06	30.80	.1889	
5....	.2634	12.50	13.55	1:1.08	26.05	.1907	
6....	.2981	14.65	14.90	1:1.01	29.55	.1903	
7....	.2924	14.22	14.68	1:1.03	28.90	.1908	
8....	.2895	13.80	14.90	1:1.07	28.70	.1903	.1902
		200cc of freshly boiled, distilled water was used.					
9....	.3290	16.51	16.05	1: .97	32.56	.1906	
10....	.2771	13.62	13.78	1:1.01	27.40	.1908	
11....	.2634	12.77	13.23	1:1.03	26.00	.1911	.19083
		300cc of freshly boiled, distilled water was used.					
12....	.2898	13.40	15.00	1:1.12	28.40	.1925	
13....	.2184	10.45	11.05	1:1.06	21.50	.1916	
14....	.3180	14.65	16.60	1:1.13	31.25	.1920	.19203
		400cc of freshly boiled, distilled water was used.					
15....	.1895	9.35	9.77	1:1.04	19.12	.1895	
16....	.3583	17.10	18.10	1:1.05	35.20	.1920	
17....	.2258	10.70	11.70	1:1.09	22.40	.1910	
18....	.2244	10.60	11.55	1:1.09	22.15	.1911	.1909

Average ratio of volumes, P.P.:M.O..... 1:1.054

Data for potassium carbonate and the bicarbonate. In tables 3 and 4 ordinary chemically pure potassium carbonate was used after heating it for some time to 255° and allowing it to cool in a desiccator. For table 3 the acid used was approximately one-tenth normal while in table 4 the acid was approximately two-tenths. Since the problem now was to study the relative volumes in the first half of the titration (phenolphthalein as indicator) as compared with the last half (methyl orange as indicator) the exact normality of the acid was not important. In the first experiment of table 3 and the last three experiments of table 4 ordinary distilled water was used. In the others freshly boiled distilled water was employed as solvent for the car-

bonate. In experiment 1 of table 3 the volume for the phenolphthalein titration is evidently far wrong though the total is only slightly too high. For some reason the relative volumes in the two parts of the titration are not constant as would be expected. This part of the work was done in the first part of the investigation and it is possible that the end point for phenolphthalein was not as accurately judged as in later work.

TABLE III.

Exp. No.	Wt. of K_2CO_3	Vol. HCl P.P.	Vol. HCl M.O.	Ratio P.P.:M.O.	Vol. HCl total	Normality found	Average
1.....	.5131	32.31	42.49	.....	74.8	.09941	
2.....	.1766	12.4	13.5	1:1.09	25.9	.09881	
3.....	.1411	9.58	11.32	1:1.19	20.90	.09785	
4.....	.1230	9.2	9.05	1: .98	18.25	.09767	
5.....	.0768	5.45	6.3	1:1.15	11.75	.09474	

Disregarding the last which is far too low the average normality is .09843, and the greatest variation from this is one per cent.

TABLE IV.

Exp. No.	Wt. of K_2CO_3	Vol. HCl P.P.	Vol. HCl M.O.	Ratio P.P.:M.O	Vol. HCl total	Normality found	Average
1.....	.2706	9.00	9.5	1:1.06	18.5	.2119	
2.....	.3545	11.7	11.8	1:1.00†	23.5	.2180	
3.....	.2138	7.2	7.2	1:1.00	14.4	.2152	
4.....	.2126	7.00	7.2	1:1.03	14.2	.2169	
5.....	.3509	10.9	12.6	1:1.15	23.5	.2164	
6.....	.3023	9.6	10.4	1:1.08	20.00	.2190	
7.....	.4160	12.2	15.5	1:1.27	27.7	.2176	.2164

If No. 1 is omitted the average normality is .2172, and the greatest variation from this average is less than one per cent, while the variation between the lowest and highest is less than two per cent. In the first four experiments of this table the volumes in the two parts of the titration are nearly the same, and much nearer than in any of the rest of the work. They are within experimental error of what theory demands.

The following work was done with potassium carbonate made by heating to 300°, the highest grade of purity of the bicarbonate. In the first four experiments ordinary distilled water was used as solvent. With the others freshly boiled water was used. The carbonate is quite deliquescent and so after heating the carbonate was cooled in a closed weighing bottle enclosed in a desiccator. The acid used had a normality .194.

TABLE V.

Exp. No.	Wt. of K_2CO_3	Vol. HCl Phe. Phth.	Vol. HCl M.O.	Ratio P.P.:M.O.	Vol. HCl total	Normality found	Average
1.....	.4029	14.3	16.2	1:1.15	30.5	.1908	
2.....	.6444	23.8	25.15	1:1.05	48.95	.1904	
3.....	.2522	8.82	10.72	1:1.21	19.54	.1870	
4.....	.4690	17.08	18.52	1:1.08	35.60	.1911	
5.....	.5098	18.30	20.50	1:1.12	38.80	.1904	
6.....	.3588	13.15	14.15	1:10.7	27.30	.1901	
7.....	.3010	11.00	12.20	1:1.11	23.2	.1880	
8.....	.3614	13.30	14.10	1:1.06	27.4	.1911	
9.....	.4094	14.9	16.10	1:1.07	31.00	.1914	.19007

Average of the last four in which the water had been boiled, .19025. Omitting the two which are abnormally low, for some unknown reason, the average of the seven is .1908. In every case the volume of acid in the first part of the titration is appreciably less than in the second part. The volume in the second part is quite consistently nearly 1.1 times that of the first part. The notable exception is where the calculated normality is unusually low indicating that the volume used was too high, possibly in the second part.

The following titrations of the acid (used above) were made directly with the potassium bicarbonate from which the carbonate used in table 5 was prepared. Ordinary distilled water was used as there seems no reason why free carbonic acid in the water should effect the volume of acid needed.

TABLE VI.

Exp. No.	Weight $KHCO_3$	Volume HCl	Wt. perce HCl^-	Normality found	Average
1.....	.9263.	48.5	.019099	.1910	
2.....	.5832	30.6	.019059	.1906	
3.....	.7194	37.6	.019133	.1913	
4.....	.4554	23.72	.019198	.1919	.1912

Discussion of results:

The normality of acids as determined from titration against either carbonates or bicarbonates, at least this is true for dilute solutions of hydrochloric acid, has a smaller value than when determined from precipitation methods. In the case at hand the normality of hydrochloric acid as determined from precipitation of silver chloride, or when titrated against standard silver nitrate had a normality of .194. When titrated against either sodium bicarbonate or potassium bicarbonate the normality found was .191; and

when either of the carbonates, made from the bicarbonates, was used the normality was slightly less. Not only was the average less, but not one of the single determinations equaled the theoretical value, .194.

In titrating carbonates in the presence of two indicators, phenol phthalein for the first action, Na_2CO_3+HCl—$NaHCO_3+NaCl$, and methyl orange for the second action, $NaHCO_3+HCl$—H_2CO_3—NaCl, in all but two or three titrations the volumes in the second part were larger by 1.05 to 1.1 times, though the agreement was not close in the various cases. The normality of the acid calculated on the basis of the first part of the titration of sodium carbonate with phenol phthalein was on the average .1957, or slightly more than the theoretical, .194. The lowest value was .190, and the highest, .203. With potassium carbonate the corresponding average was .1996, the lowest again being .196 and the highest .207.

Conclusions:

If any conclusions are justifiable from the data presented they seem to be the following:

1. The normality of acids as found from the titrations of either carbonates or bicarbonates is below the real normality.

2. The normality found through the bicarbonates is slightly above that found through the carbonates.

3. The normality found through that part of the titration in which phenol phthalein is used as indicator is slightly above the real normality. This seems to mean that the volume of acid used in this part is less than that needed to convert the carbonate into the bicarbonate, while the volume needed to convert the bicarbonate into carbonic acid is considerably too much. The question arises, therefore, whether these indicators are the proper ones to determine the end point in carbonate titrations.

4. The water used as solvent for the carbonates should be free from carbon dioxide. At least more consistent results are secured if it is.

5. The volume of water used as solvent, beyond a reasonable minimum, does not greatly affect the result.

A MODIFICATION OF THE KJELDAHL NITROGEN PROCEDURE.

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In the ordinary method of determination of nitrogen by the Kjeldahl method, it has been customary, after completion of the digestion with sulphuric acid, to add a strong solution of sodium hydroxide. Laboratory directions given in the quantitative methods all state that the sodium hydroxide solution should be added in such a way that mixing does not occur until connections are made in the distilling apparatus and then by shaking or rotating the flask.

It has been the experience of the writer, and of others with whom he has talked on the subject, that at this point in the procedure, two objectionable possibilities are presented. It is difficult for the beginner, at least, to cause the two layers in the flask to mix slowly, and if it does take place too rapidly, the violence of the action causes some of the solution to shoot up into the condenser tube, thereby, of course, ruining the results; and even in a few cases the action has been known to have force enough to break the flask, presenting a decided element of personal risk to the worker.

Experiments have been conducted here in the Joliet Junior College laboratory, and we seem to have found a modification of the procedure which eliminates these dangers.

Our method is as follows: after completion of the digestion and subsequent cooling, dilute with 200-250 cc. of water with cooling, quickly introduce into the flask 50-75 grams of sodium hydroxide in the stick form and immediately make connections for distilling.

The sticks of sodium hydroxide quickly and quietly dissolve, and in our experiments the action has never been violent enough to cause more than moderate boiling of the mixture. In addition, this operation may be performed so quickly that very little, if any, ammonia is lost, as shown by results obtained.

We feel that we can recommend this change in the common procedure.

FUTURE SOURCES OF SULPHUR AS PLANT FOOD.

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Sulphur has always played and will continue to play a very important role in all life processes whether they be of vegetable or animal nature. Its use as a valuable plant food preceded that of commercial fertilizers and the history of early American agriculture is replete with information showing that sulphur in the form of gypsum has been beneficial in various ways to crops.[1]

It was surmised more than a century ago that the beneficial substance in gypsum was vitriolic acid or what we now recognize as the SO_4 radicle and not calcium, for the reason that plants did not respond to applications of burnt or slacked lime in a similar good manner.

The early investigators were unaware that the gypsum could induce definite chemical, bacterial and physical changes in the soil which would explain the ofttimes phenomenal result secured. Based on subsequent investigations it was discovered that such changes did occur and were partly, if not entirely, causes for enhanced yields. The most frequent cause for the increase of crops, however, was that gypsum provided the plants with available sulphur.

By comparing the sulphur content in Wolf's ash analyses the present methods of determining sulphur, it is now obvious that many investigators were misled regarding the quantity of sulphur that would be required to meet crop needs. Ideas regarding the sulphur requirements of plants underwent a rapid evolution when it was shown that only an insignificant part of the total sulphur was retained in the ash. Bacon has stated,[2] "From obscurity sulphur gained prominence over night and it was indeed startling to realize that, on the average, plants required more sulphur than phosphorus."

Previous to the discovery of the large amount of sulphur required by various crops, Dymond, Hughes and

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[1]Crocker, William. The History of Agricultural Gypsum. Published by The Gypsum Industries, Chicago, Ill., 1922.

[2]Bacon, Raymond F., Relation of Sulphur to Fertilizers and Plant Growth, American Chemical Society, Milwaukee, September 13, 1922.

Jupe,[3] following observations with soils at Essex, England, deduced: "There is not enough sulphuric acid in the soil or supplied by rains for heavy yielding crops rich in albuminoids, either for the production of greater yields or highest feeding value and for such crops it should be included in the artificial manure."

Since no checks were made to determine the value of sulphur as plant food in early fertilizer experiments conducted in the United States it was impossible to ascertain the response of plants to sulphur treatment. This can be appreciated when one considers the composition of a 4-8-6 fertilizer containing in part ammonium sulphate, acid phosphate, and sulphate of potash. In a mixture of this kind the total ammonia nitrogen is 80 pounds; potash, 120 pounds; phosphoric acid, 160 pounds; and the sulphur trioxide, 394 pounds. Fertilizer manufacturers have supplied sulphur in large amounts in their mixtures.

In the west where the soils have not been treated with sulphur-containing fertilizers, it has been possible to differentiate between the importance of this element and with phosphorus. Olson and St. John[4] in the state of Washington, increased the yields of legumes 100 to 200 per cent with applications of gypsum and sulphuric acid. Reimer and Tartar[5] in Oregon obtained similar results and proved beyond any question of doubt that there was a real need for sulphur as plant food material.

[3]Dymond, T. S., Hughes, F., and Jupe., C. W. C., The Influence of Sulphates as Manure upon the Yield and Feeding Value of Crops., Journal Agricultural Science, 1:217-229, 1905.

[4]Olson, George A. and St. John, J. L., An Investigation of Sulphur as Plant Food, Washington Experiment Station, Bulletin 165, 1921.

[5]Reimer, F. C. and Tartar, H. V., Sulphur as a Fertilizer for Alfalfa in Southern Oregon, Oregon Experiment Station Bulletin 163, 1919.

Increase Per Acre Over the Cost of Materials Produced by Applications of Phosphorus, Gypsum and Lime.

NET INCREASE OVER CHECK

Crop	Phosphorus	Gypsum	Lime
Alfalfa	$8.14	$49.99	$4.08
Sweet Clover	6.30	38.25	2.85
Meadow Mixture	(a) .71	21.53	(a) 4.21
Red Clover	4.22	18.55	(a) 1.09
Wheat	(a) .23	18.89	4.53

a-Loss.

Likewise it has been shown that there is in Idaho soils a sulphur poverty. McDole and Christ[6] have stated:

"While phosphorus and lime have produced some increase in production, the gypsum has proved to be the most profitable material to use."

A very good idea of the value of the gypsum as a source of sulphur is manifested in the following table which appears on page 20 of Bulletin No. 136 of the Idaho Agricultural Experiment Station.

If acid phosphate which is approximately one-half gypsum had been applied instead of mono-calcium phosphate and gypsum the possibilities are that the increased yields would have been credited to phosphorus. From this and other similar experiments, there are reasons to believe that many of the results with acid phosphate have been misinterpreted in the past.

On page 26 of Soils Report 33 of the Illinois Agricultural Experiment Station it is shown that wheat, straw, corn stover, oat straw, soy bean hay, and alfalfa hay contain 9 to 100 per cent more sulphur than phosphorus. The amount of sulphur which is annually leached from soils and carried down streams into salt waters is enormous as compared with phosphorus.

The Ohio River[7] carries away annually about 2,200,000 tons of sulphur in solution which is equivalent to the sulphur in approximately 12 million tons of gypsum. This loss of sulphur is more than three times the quantity that is applied in the form of fertilizer. In the drainage of the Mississippi Valley approximately 6,700,000 tons of sulphur in solution annually are emptied into the Gulf of Mexico. In addition there are about 3,400,000 tons more in the sediment which annually empties into the Gulf of Mexico. In the United States as a whole the writer has estimated that 20,000,000 tons of sulphur are dissolved in the waters which pass down stream and empty into the Gulf of Mexico, the Atlantic and the Pacific Oceans.

Besides the enormous loss of sulphur other plant foods are carried away in solution and sediment to augment the ocean salinity and build up the ocean floor. In the Mississip-

[6]McDole, G. R. and Christ, J. H., Farming Practices for the Cut-Over Lands of Northern Idaho., Idaho Experiment Station Bulletin 136, 1925.

[7]McHargue, J. S. and Peter, A. M., The Removal of Mineral Plant Food by Natural Drainage Waters, Kentucky Experiment Station, Bulletin 237, 1921.

pi Valley, it has been estimated that $4,000,000,000 of plant nutrients are lost per annum.

The taking away of our upland forests and the careless method of tilling these and other rolling lands are the direct causes for the floods and the destruction of lives and property. It is also the cause for the waste of enormous quantities of plant food materials and soil.

Knowing the causes they can be remedied. The lost soil materials such as gypsum and other calcium salts, which in the natural state helped to keep the soil open and receptive to water must be replaced and the lands unsuitable for agriculture must be reforested. The rolling land suitable for agriculture must be terraced, strip farmed, put into clover crops or grasses. By these practices it is possible to reduce losses of soil and plant food minerals and to avoid damages by floods.

We have accounted for enormous losses of sulphur and as the future welfare of our nation depends so much on the fertility of our lands it is well to consider the sources of supply of sulphur which have helped to prevent plant starvation.

There are about 600,000 tons of sulphur in the fertilizers which are annually added to soil. The principal source, however, comes from the burning of coal. The amount returned to the land if all of the sulphur in coal were volatilized would be approximately 13,400,000 tons annually or 6,000,000 tons less than is carried away in our drainage system. It is more than likely that the amount of sulphur escaping into the air does not exceed 7,000,000 tons annually or 12,400,000 tons less than is removed. This is in accord with Sir A. D. Hall's views[8] that the rains on the average wash three times as much sulphur out of the soil as is carried down from the air.

Most of the coal is consumed in the industrial centers and these are also the places where most of the sulphur in the rain water appears. The polluting of the air with smoke is objectionable from a health standpoint. Not only are the visible rays which we call light shut off but also the violet light rays which medical science has discovered are essential

[8]Hall, A. D., The Soil, and Introduction to the Scientific Study of the Growth of Crops New York, 1915.

to life. There is also great economic waste in permitting the carbon to escape as smoke.

It has been demonstrated that coal can be converted into fuel oil and according to views expressed by experts connected with the United States Federal Bureau of Mines this oil will soon take the place of coal as fuel and the skies in the great municipalities will then be as clear as those in the open country. Simultaneously more of the ultra violet light rays and less of the sulphur will be made available.

For economic reasons the trend in the manufacture of fertilizers is toward the production of highly concentrated plant foods, such as ammonium phosphate, potassium phosphate, phophoric acid, urea, ammonium nitrate, and leuna saltpeter. In the state of Ohio[9] it is already noted that the farmers are purchasing more units of nitrogen, potassium and phosphorus per ton of fertilizer than before, and competition will require additional units of these elements. It will have the tendency to eliminate sulphur as one of the products, because it is considered economically unprofitable at the present time to transport sulphur great distances. With the elimination of sulphur in the fuel the needs for this plant food may be more keenly felt and as a result effort will be made to recover it in the waste products. Fortunately such changes in our supply of sulphur as are bound to occur will not seriously affect agriculture. This is due to the fact that we have large deposits of gypsum strategically located near various farm centers in the United States.

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[9]Barnes, E. E., Trend of Fertilizer Sales in Ohio, Ohio Experiment Station, Bimonthly Bulletin, March-April, 1927.

SOME OBSERVATIONS ON FUEL OILS AND THEIR ANALYSES.

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Custom has made the specific gravity of oils the most important factor in their classification. The first question that is asked by the average customer is for information regarding the "gravity" of the oil. Reports of production and sales are made in this common term of classification. The importance of the specific gravity of an oil, as an estimate of its value, is probably due to the opinion that the temperature of flashing, firing and distillation are lower for light oils than for heavy oils. This opinion is based upon experience with "straight run" oils or fractions distilled from a particular crude oil. The oil mixtures marketed under the very broad term of "Fuel Oil," present a different problem in estimating the properties from the hydrometer reading.

A scientific foundation for an industry eliminates the necessity of opinion in matters of vital importance. The value of an opinion, however, depends entirely upon the amount of experience upon which it is based. An opinion, that is given with a background of many years of experience, should not be underestimated and is well worth careful consideration. This experience factor can be eliminated only by careful experimentation and study, in correlating the facts.

Data on Oils From the Entire Country.

In reviewing the results of several hundred tests on fuel oils of all types, it seems that a comparison of the properties of these oils should show the relationship of the properties of fuel oils that are commonly used. The group of analyses, which are tabulated in this paper, were made on samples that have been received from about half of the states of the Union. They represent oils that are being used in oil burners from the Atlantic seaboard to the Pacific coast and from the Gulf to Canada, including oils from widely separated localities.

The Method of Tabulation.

The best method of tabulation, of the results of these analyses, appears to be on the basis of the specific gravity of the oil, corrected to 60 degrees Fahrenheit and expressed in degrees Baume. The specific gravity of the oil is a definite measure of the number of pounds a gallon of oil weighs. This method of arrangement of the analyses should give some insight into the relationship of the properties of heavy and light oils.

In comparing oils of known specific gravity, we expect that the oil of higher Baume value to be more clean and clear, and, in general, to be more satisfactory in the operation of the burner. Records of these properties of the oils have been made but they are difficult to place in a table of data and they will be discussed only in comparison.

The variations in the analyses of the oils under consideration are shown in table 1. The first column gives the specific gravities of the oils, in Baume degrees, and these values are placed in order of their increasing magnitude. Under each of the properties of the oils the numbers are the temperatures in Fahrenheit degrees, the first number being the low value and the second is the high value found for oils of the given specific gravity. All of the oils that were analyzed gave results within the limits shown in table 1. The low values of each of the properties do not, in general, represent the same oil, for the variation in the properties were not constant. The percentages given in the column under "end point" represent the percentage of the oil of unknown end point.

Sufficient Data for Average.

In order to determine whether a sufficient number of analyses have been considered, to be valuable as a basis for a comparison, the mean and average values were made for a large number of the properties. The mean value is procured by arranging the results, for oils of the same specific gravity, in the order of their values and taking the one with an equal number of analyses above and below it. This value is compared to the average results and dividing by the number of oils analysed. Two of these comparisons will illustrate the correlation of the data in table 1. The oils

of 34 degree Baume gravity have a mean flash point of 190°F. and an average flash point of 192°F., the correlation of the data being practically one percent. The mean flash point of the 37° Baume oils is 178°F while the average flash point of these oils is 180°F. The correlation of the data for this group of oils is 1.1 percent. These results indicate that a sufficient number of analyses are included in the table to represent this class of oils. The correlation of the oils of 30° Baume and below do not not give as good results and their properties seem to vary through wide limits. The observations made of these oils during the analyses, impress one that the properties have a definite relation to the type of oil analysed and that the mixtures, composing the oils, are as widely divergent as the properties shown by the analyses.

A Comparison of the Properties.

It is interesting to compare the oils of different specific gravities, which we would consider of very much different value, for we often find that the facts may be the reverse of our opinion of the oils. We find an oil which is included in table 1 with the 28° Baume group that has properties which compares favorably with oils which have a specific gravity 10° higher. This is also true of oils in the 29° Baume group and is not an isolated example. On the other hand, we find oils of 37° and 38° Baume that, from analysis, we would estimate as a very much lower specific gravity. In Table 2 a comparison of these oils is made which gives a striking illustration of the lack of coordination between the specific gravities of the oils and the results of their analyses.

The Appearance is Not Helpful.

A careful record was kept of the appearance of all of the oils analysed and the color, transparency, opalescence, etc., of the samples were tabulated and the oils classified according to the above properties. From this data no conclusions could be drawn regarding a relationship of the appearance of an oil and its analysis. The opinion that a clear oil has lower temperatures of flashing, firing and dis-

tillation does not seem to be indicated by the data. In fact, a dark colored and opaque oil may be much higher grade than a clean straw-colored oil of the same gravity. The possibilities of this variation is shown by a comparison of the appearance of the oils in table 2. The 28°, 37° and 38° Baume oils in this table were of light color and clear while the 29° Baume oil was black and opaque.

Conclusion.

A study of a large number of analyses of fuel oils does not show any close relationship between the specific gravity and appearance of the oil or the results of the analyses. The oils studied were representative of the class of oils sold in all parts of the United States for use in oil burners. The label "Fuel Oil" seems to be acceptable for any oil mixture or conglomeration that can be put together.

A more practical classification or grading of fuel oils could be made if based upon the proper standards. The specifications for standard oils of each degree Baume could be used as a basis for classification. Fuel oils that conform to these average qualities could be designated as a "Class B" grade. The oils of the same degree Baume which gave lower temperatures of distillation, etc., could be designated as "Class A" while the poorer oils, of the same specific gravity would be "Class C". The advantage of a classification of this type, would be the differentiation between oils that are properly purified and the oil garbage which, at present, can be dumped on the market at a par with the better oils.

The standardization of any part of an industry should be based upon a large quantity of experimental data and experience. The limits of each class of oils should be set by first studying many oils of known mixtures and a study of their fitness for use in the present designs of oil burners. The task would not be an easy one but an intelligent classification of oils would be a big advantage in helping the consumer to purchase fuel oils and know the exact quality of the oil that he buys.

	28°	29°	37°	38°
Flash Point	178	154	214	237
Fire Point	194	192	235	250
Distillation:				
Starting	375	329	298	484
End	645	690	690	750

Degree Baume	Flash Point		Fire Point		Starting Point		End Point	
	Low	High	Low	High	Low	High	Low	High
41	136	173	151	192	266	375	550	590
40	156	179	172	189	300	410	490	565
39	155	233	173	249	218	410	515	28%
38	148	237	174	250	245	484	465	40%
37	151	214	162	235	282	455	525	28%
36	160	219	167	253	360	440	530	45%
35	154	228	173	252	322	450	540	9%
34	159	262	172	279	360	500	525	60%
33	147	239	158	250	365	452	600	33%
32	162	213	184	227	255	455	7%	35%
31	173	246	188	260	341	476	6%	47%
30	197	298	204	311	400	563	32%	82%
29	154	195	192	210	329	375	28%	42%
28	178	240	194	260	375	581	6%	65%
27	199	234	218	258	386	565	22%	77%

PROGRESS IN SCIENCE.

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PART I.

We live in an age of progress, a time when old creeds, old dogmas and false theories are giving way to the light of truth; the veil of darkness is gradually lifting and man is now favored as never before by having some really accurate notions of the world in which he dwells. Thus, as the search for truth advances, the plane of civilization is raised. In the words of the wise old saying, "Today is better than yesterday; tomorrow will be better than today."

Professor John Dewey once said, "The future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind." The work of discovery has been going on from year to year until now it is said that we have eighty-eight known chemical elements, and these are the outcome of an organic evolution. Science has no equal in the revelation of knowledge in the world and it is progressing in spite of anything man may place in its way, for it is following nature's law.

How futile to oppose it. It would be as reasonable to attempt to turn back the tide as to try to change its course in its onward march. Truth is what the world needs and the working of the principle of evolution is nature's method of revealing the truth. The highest ambition of the scientist is to help make known the truth. Surely, searching for knowledge is no crime at the present day, for it truthfully may be said that the object of science is to discover and proclaim in truth and in fact the phenomena of the cosmos, thereby resulting in blessings to the inhabitants of the earth.

Thanks to the age of freedom of thought the days of Bruno are gone. The days of Galileo are also gone. Even he, after having been compelled to admit against his better reason and judgment the statement which he did not believe, and after placing his name on the dotted line exclaimed, "Epur si muove" (the earth) "still it does move." But while we note with satisfaction the advance science is

making, let us not forget that even to this day the three hundred years conflict for intellectual freedom against ignorance and superstition, which began in the days of those intellectual giants Bacon, Des Cartes and Galileo, has not entirely closed. It has been a conflict against ignorance, tradition and vested rights. "One of the most dangerous pieces of legislation ever passed," said Reverend Shailer Mathews, "is the Tennessee law prohibiting instruction of the evolutionary theory of man's origin." Following the action of Tennessee, observe the trend in Mississippi, Georgia, Oklahoma and elsewhere. Doubt not that our national legislature at Washington may yet be appealed to by anti-evolutionists. Has it come to this? Are we going back to the dark ages? Are people to be robbed of their birthright to do their own thinking?

To some people the name science has an alarming sound. The very utterance of the word causes them to have serious forebodings; they seem to think that something terrible is going to happen when the name science is mentioned. Some people have become so much disturbed upon hearing of new discoveries that they appear to fear that the scientist will, through the disintegration of the atom, start a conflagration that will explode this old earth of ours. They have doubtless come honestly by such belief, never having acquainted themselves with the mission that science is performing in the world. The evidences are all around them and still they fail to observe them. Are they getting nearer the truth when they shut their eyes and close their ears to the book of nature and declare that those who read from nature and nature's laws are wrong? Is the man who delves into the bowels of the earth and brings forth evidences of its age to be scourged for his efforts simply because he arrives at conclusions that differ from those who shut the book and will not read? He who points his telescope towards the stars in search of worlds unknown, who strives with earnest zeal to bring a little nearer the solution of the mystic deep, perchance to discover a world of beings not unlike himself—is not his work worthy of recognition and praise? He who plods with unfaltering tread in search of truth through the fields of the great unknown, making discoveries by the use of the spectroscope that are adding

to the plane of knowledge, resulting in benefits and happiness to the human race, is he to be scorned because he cannot accept the dictum of him who has steeled his mind against investigation and proof of nature's yet unsolved problems? Are the scoffers of science any more certain that they are right in their assumed position regarding the origin of men simply because they have read the Book of books and have placed their own interpretation thereon than their neighbor who is likewise familiar with the same great record and has an interpretation that differs from theirs? If both are candid, fairminded, intelligent and sincere, imbued with the desire to know the truth, one should have the same right to his interpretation as the other.

Mr. Donald A. Laird in the columns of Life gave the repartee which passed between the Bishop and Mr. Huxley. The Bishop, turning to Huxley with smiling insolence, begged to know whether it was through his grandfather or his grandmother that he claimed his descent from the monkey. Mr. Huxley, calmly and deliberately rising, replied that he was not ashamed of having a monkey for an ancestor but he would be ashamed to be connected with a man who used great gifts to obscure the truth. The cut was deep; the effect was tremendous; the Bishop said no more.

However, a brighter day for the natural sciences has dawned and they are coming into their own, and while as much cannot be said for the social sciences, hope lies in intelligence for the future. The old ways have been tried and found wanting.

When this old earth, called the "geocentric sphere of the universe," became a wandering planet circling around a central sun, the cause of truth advanced to higher ground. All attempts since 1450 A. D. to enslave the world either physically, mentally or spiritually have ended in failure.

The human race will be advancing toward true culture and greatness when with sober thought and sincerity of purpose it takes courage to question all things, weigh all things, prove all things, making knowledge and understanding seasoned with love for fellow man the foundation upon which to build a higher, a better and a more advanced civilization.

We live in an ever changing world. The changes resulting from recent discoveries are so great that the rank and file of people are not ready to receive them. The leaders in science and investigation have made too rapid strides for the people. The great discoveries of radio activity, whereby the music of the spheres has been harnessed by the hand of man resulting in sweetest harmonies that charm the world, the X-rays, the divisibility of the atom, the discovery of the electron, have swept the multitude off their feet. The explorations of the physicists and chemists in the world of atoms and molecules, electrons and protons have been crowned with miraculous triumph in the modern fields of science. The harnessing of electrons i. e. causing them to flow through wires as an electric current whereby lamps are lighted, engines propelled, cars run, factories operated and great systems of transportation carried on are among the marvels of the age that have been wrought by scientists and all for the convenience, advancement and betterment of the human race. A most important phase of scientific investigation of the material universe came with the discovery of radium in 1898, a new property of matter.

No idea has been so powerful in the fashioning of knowledge as the simple but profound thought of evolution that the past is the parent of the present, and the present the parent of the future. Evolution has influenced all the sciences forcing its devotees to think of everything as with a history behind it.

The solar system, the earth, the great cordilleras and the mighty ocean, the rocks, the crystals, the fauna and the flora, even man himself, all must be seen and recognized as the outcome of a long process of development.

The spectroscope, that most wonderful instrument with which the scientist is able to solve many of the questions pertaining to the stellar world, that but a few years ago were unsolved, to it we owe our knowledge of the composition of the sun and stars. It is said that the spectroscope will detect the millionth part of a milligram of matter and still the limit is not reached, that it will detect the nature of the forms of matter trillions of miles away and that it will measure the velocity with which these forms of

matter are moving with slight variation. Must we not confess, as has been said, that it is the greatest instrument ever devised by the brain and hand of man.

Science teaches that things came through a logical order; that there is a controlling power and that this power controls all things; call it God or what you will, that this power has often been misunderstood and that science is striving for the truth. "Seek the truth and the truth shall make you free" is a most salutary doctrine for both science and religion.

The scientist does not claim to know whether the universe is finite or infinite, temporal or eternal and he makes no claim where there are no facts to warrant him. So far as is known in science today there is no evidence of spontaneous generation.

The scientist having divorced nature from chance, it follows as a logical sequence that nature's order of procedure is not to be turned and twisted to suit the whims, fancies and prejudices of man, but rather its course appears immutable, unchangeable despite the false theories of men.

Although man is but an infinitesimal part of that vast world, still it appears that he is endowed with a mind and a capacity that raises him to a station far above all other sublimary creatures. It behooves man therefore, as an intellectual human being to try to form true conceptions of the diversity of the things that go to make up the great system of nature's complexity.

The true scientist will not go so far as to assert that such has always been the case nor will he dogmatise that so and so is the only way, but when he is asked to concede that such always has been the case and the only way, he has a right to weigh the proof.

But I shall not carry these suggestions further; it is not my purpose on this occasion in the few minutes allotted to discuss the science of government nor the conflict of the age-old question, science and the Bible, but I will express my conclusions in these few words, that I believe there is no conflict when rightly understood and that hope rises in the belief that this is gradually becoming recognized.

PART II.

What I shall offer concerns recent discoveries in the field of one of the oldest, most wonderful and at the same time most progressive of the sciences pursued by man. The field of its operations is so vast and its discoveries so astounding that the intellect is almost lost in wonder when it sweeps forth into space to view an infinitesimal fraction of the vast universe.

Viewing the subject on broad lines, I shall refer to a recent discovery of scientific research in this all-absorbing subject which leads beyond the universe in which we live.

The data that has been taken, the discoveries that have been made, come from authority sufficiently eminent to dispel any doubts that another galaxy, another universe has been sighted.

I now call your attention to an aerial tour which you are invited to take with me through the most stupendous route ever taken by man into the depths of space to catch a glimpse of the discovery in astronomical science recently taken through the great one hundred inch reflector located at Mount Wilson, the largest telescope in the world.

Dr. Edwin Hubble of Mount Wilson recently pushed out the limits beyond our universe and brought a little nearer the mysteries in endless space of the great heavenly objects, among others the great spiral nebulae. I may say before starting on our trip that it is said this wonder of wonders, as it may be described, appears like a luminous haze or cloud in the sky with numerous faint stars appearing at the outer edge, located from earth's viewpoint in the constellation Andromeda.

Our journey will be somewhat extended although deep with interest all the way but I warn you that we shall travel at a rate of speed that may chill your circulatory system owing to the rarification of the ethereal air through which we shall pass, and remind you that a life insurance policy payable to your wife may be in order, for there is a rule in law that after an absence of seven years, death is presumed. However, let no one be alarmed for I guarantee that we shall return safely, which is more than the men who propose visiting the moon are able to offer at present.

First, you will think of the solar system with its sublimity and beauty, eight planets revolving round a central sun, that great body, the source of light and heat with a diameter of 865,000 miles. If its rays were withheld for one month from the earth, it is said, life thereon would cease. That monarch of the sky lies bathed in an azure blue, bespangled with diamonds whose beauty and brilliance transcends the genius of man to describe. No wonder that the great composer of harmony was inspired to write "The Heavens are telling the Glory of God." Throw open the windows of your imagination, for it will do you no harm to lay aside thoughts of business and let your minds roam for a while through the fathomless depths of immensity's realm.

You have not had an opportunity of taking just such a trip as this perhaps and to all that is passing I shall ask your close attention.

Moving out from the central orb, old sol, we pass the first, the smallest and nearest neighbor, planet Mercury which is thirty-six million miles away, taking three and one-half minutes to reach.

Lead on and salute with a smile bright Venus, the Goddess of Love and Beauty, whose distance is sixty-seven million miles from our central sun and whose beauty we so often behold as morning or evening star, and which, like Mercury, sometimes passes in transit because it lies within the earth's ecliptic.

We are now passing old earth on our right, ninety three million miles distant from our starting point, taking eight minutes to reach, which was once supposed to be the center of the universe, to doubt which brought on a controversy that lasted long and serious, leading on to far off Mars, the God of War, which revolves around the sun in six hundred eighty-seven days, with its two moons discovered in 1877, the planet that on the 22nd of August, 1924, approached within thirty-five million miles of our earth at perihelion and which was viewed by astronomers with great satisfaction, the nearest it will be for 120 years. We shall ski through her canals and prove whether or not Lowell might have said a world peopled with beings not unlike ourselves, although our latest authority doubts the

probability. Here, glance back to earth which we passed but 14 minutes ago and observe that she appears like a faint star in the distance. Does your mind grasp the thought of the grand panorama wherein millions of worlds like streams of light are moving before you with lightning speed and brilliance unsurpassed?

Keep your imagination working; we are moving now with lightning speed. Continue the long and bumpy road, stopping a moment to view the remains of a once supposed wandering world, often looked for but never found, fragments of which were called the asteroids, goddesses familiar to Homer in his day. Modern research tells us that they are not the remains of a planet, but rather scattered meteoric material which was prevented from becoming consolidated into a single world by the attraction of the giant wanderer in the solar system. Advance, paying our respects to the largest known planet, old Jupiter, nearly thirteen hundred times larger than our earth, with his nine satellites, where moonlight never fails to light the pathway of the mythological god of power, and hear his thunder bolts as they roll away and make the very heavens tremble.

It is interesting to note that the outer moons of Jupiter revolve around the planet in the reverse order to other moons, and it was the discovery of the moons of Jupiter by Galileo, January 7, 1610, that solved the perplexing question and proved the theory that the earth and other planets revolve around the sun, a boon that science has bestowed upon the human race, proving that the sun and not the earth was the center of the solar system, the reverse of which had been held for 2000 years.

Here lead on to distant Saturn with her eight moons and her three ring circles. Pluck off one of these rings composed of meteoric iron and stone to lay a track to Uranus. Saturn with her rings appears as one of the most interesting of the planets. Work fast for she revolves on her axis once in ten hours, thus making the hours for labor very short. We are now about 480 million miles from our starting point and approaching the once outward rim of the solar system; here ponder a moment, wondering what lies beyond for it was here that science paused and pondered for many years whether or not any other planet lay beyond.

The irregularities in the motion of Uranus led Leverier to suspect that another planet existed outside of Uranus. Resuming our journey, we are now traveling on that almost endless trail, tired, silent and discouraged when someone shouts: "Look out there! Be Careful!" There comes a comet headed straight for the sun, a molten mass like a million rockets, seething and hissing with lightning speed as we pass through its tail. Were we back on earth we would call it a meteor shower. Baade's comet was a strange phenomenon which was headed from the sun, which is contrary to the observed law of comets, and nobody as yet knows why. Newton's laws of motion were almost overcome.

Advancing, we are hopeful that the last far off wanderer will be reached. Galle of Berlin University was rewarded for his search, for Neptune was discovered the 23rd of September, 1846. A peculiar thing about Neptune is that it revolves upon its axis from east to west, just the reverse of the other planets and takes 165 years to revolve around the sun. We shall take ample time to warm ourselves and plenty of rations, for the journey that now awaits us is long and winding and dark and would be dreary but for the way leading into the galaxy of stars which lie before us and through which we must pass as the night of space rolls on, remembering that the distance we have gone is but the radius of that heleocentric system for belief in which men suffered and died. Dr. Shapley of Harvard College estimates that the group of stars which astronomers call the galaxy is about 300,000 light years from side to side, a light year being the distance light travels in one year at the rate of 186,000 miles per second, a distance of 6 billion miles, but hold your estimates a little longer.

Resuming our journey we are now about to take a leap into the dark; we have gone two billion seven hundred ninety-two million miles and our brilliant old sun has faded into a dim, distant star, while dear old earth has long since vanished from sight. We are now to venture into a region where we shall have no longer clear lights to guide us. We now bid "goodbye" to moons and planets and are going out to roam among the suns of the stellar world. Tremendous as are the distances of the solar system, the widest sweep of the planetary orbits sink into insignificance compared

with the distances which separate from us even the nearest fixed star. Buckle up your belt, take up the slack, for the absolute cold of 458 degrees Fahrenheit through which we have passed has had a tendency to reduce your weight, turn on the power and let her go, forsaking the horns of Neptune, for he, even he, is yet relatively near our starting point. Pass on and out into the stellar world where all is dark and few travelers have been, to whose expanse the distance now traveled is, in comparison, just begun. Go on and on and on; go on; forget that we have passed Alpha Centaura, the nearest fixed star, more than twenty-five trillion miles from our starting point as onwards we pass along the glittering road where diamonds are falling and fading from sight. We have passed the confines of Vega, Capella, Canopas, Betelgeuse and the horns of Orion. Betelgeuse leaped into prominence in 1920 when Michelson measured its diameter which he estimated to be more than two hundred million miles, and it is stated that its size has probably been under-estimated. Recently it has been exceeded by Myra whose diameter is now thought by Michelson to be 250 million miles. Lend one thought to these mighty distances. Even these, however, are exceeded by Antares the largest star known to astronomy which is estimated to have a diameter of four hundred million miles and whose brightness is estimated at 5000 times the brightness of our sun. Does it seem like wisdom for the opponents of science to deny the unveiling of the wonders of the universe to the youth of the land and place an age limit of it all at 6000 years? Such a claim becomes an insult to human reason and intelligence. How wonderful are the works of Deity. Continue the magic flight until we have pierced and passed the star clusters, the nebulae, the star dust out of which it is believed worlds are formed, yea, the Magellanic clouds and the great white way consisting of myriads of suns many of which are moving at the rate of 200 miles per second encircling the heavens whose diminishing incandescent gleam shall have faded into night, and remember that we have even now but reached a fractional part, the one-fourth part of that vast expanse we yet must pass to come within a glinting gleam of that yet unexplored universe to which light in its travels to reach, moving at the

enormous speed of one hundred eighty-six thousand three hundred miles per second, would require more than one million years to span. Immensity, infinity itself—wake up men! Wake up! Old earth is vanished from sight. Our sun's lost in the fathomless deep; our stars are faded into night. We have nothing left but ourselves and space, even time is forgotten and gone; Einstein's Theory is but theory after all; the faint star cloud, the last cluster to pass, has now faded into night. And so it is! It must be true for all have fallen fast asleep while here I sit steering this car through endless space, a distant universe to find.

Roll on, thou deep and dark ocean of space, with speed of thought roll on. Roll on while the stars, the suns, and the galaxies have faded into night, while the dream comes over us that all is lost—but see! A gleam of hope! Another world is coming into view. Like a fleecy cloud she comes! She comes with lightning flash. She comes to view; behold a star; behold, a sun; behold, a myriad of suns; behold, an island universe (?)— and so it is!

Out there, above, below, beyond, outstretched a boundless universe. Far as the unpierced depths that limit swift imagination's flight, unending orbs are mingled in mazy motions, immutably fulfilling eternal nature's laws in a wilderness of perfect harmony. Eureka is our reward, for here we pass the outward portal of this new universe. All honor to Hubble who hath led us on. We shall soon be there for now the brakes are closing down, we have reached the first lap of our journey, the object of our tour and the name of this unexplored universe, the great spiral nebulae, no longer peering through the constellation, Andromeda, but shining in all its refulgence and beauty.

I have brought you here and have dealt with this subject, not as idle speculation, but rather to afford a little recreation for men of thought, and some suggestion of the immensity of the universe in which we live, through which we came. The thought of Deity was greater, nobler and wiser than to leave the destiny of cosmos to the narrow whims and prejudices against His laws and handiwork for, it is now believed outside, beyond, around and above all that we know or see, there are other suns and worlds and systems. Yea, even so like this, a universe we now behold

transcending in distance anything hitherto known to the mind of man. And now as we wait a moment, may we not query that if we had the great reflector with which to make the observation, would not our own galaxy of stars from whence we came appear not unlike the great nebulae that we have traveled so far to reach? I should like to pause and ponder with you the transcendent beauties of this vast universe and to roam at will through endless space, but I promised you that we would return and in view of the fact that the way is long and air craft slow, I shall take you back, not in the same way, not at the same speed at which we came, but with the speed of thought which has safely brought us here and will safely take us back to our native planet and without stopping along the road to gather the gems that have strewn our pathway. The next station will be dear old earth and here we are, all out, safe and sound. We have been gone more than one million years, have traveled twelve quintrillion miles. What the next era shall bring we know not. We are lost in wonder and only may say turn on the lights and let the flame of intellectual freedom burn that it may lead mankind to a higher and nobler station than he has yet attained. Let the truth be made known to all people until the dross of ignorance and superstition are purged and burned away.

PAPERS IN GEOGRAPHY AND GEOLOGY

SECTION, JOLIET.

RICE GROWING IN THE UPPER MISSISSIPPI VALLEY.

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A chance remark has recently been responsible for a very great northward extension of the rice industry. Four years ago, a disgusted tenant of river-bottom land was talking with his landlord about prospects on the farm which was about two miles from Elsberry, Missouri, and 68 miles north of St. Louis. Said the tenant, who had once been a Louisiana rice farmer, "This would make a better rice farm than anything else." While he spoke, his eyes rested upon wet weedy fields. The landlord was wide awake; "Do you mean it?" he asked. "Yes, if you will move it south where it is warm enough for rice to grow," the dialogue went on. The owner of the farm, Alvin Rowe of Galesburg, Ill., was a manufacturer of gates and other farm equipment. He had occasion, soon after, to make a trip to Louisiana, Texas, and Arkansas. While there he made it his business to investigate the rice industry. On his return, he had fully determined upon an experiment in rice growing, which he proceeded to carry on much to the disapproval of his Missouri neighbors. They all said, "This is too far north for rice"; the Missouri-Arkansas boundary district being farthest north for rice at that date (1923).

Mr. Rowe had prepared on his farm at Elsberry, Mo., a plot of sixty-five acres which were seeded with six different varieties of rice with the results shown in the following summary of the experiment:

Acres	Variety	Results
15	Honduras	Straw grew 5 to 6 ft.; failed to fill or ripen
15	Colora Jap	Yield 113 bu. per acre (short grained) poor sample
15	Lady Wright	Yield 98 bu. per acre (long grained) very satisfactory
10	Storm Proof	Yield 92 bu. per acre (straw weak)
5	Mortgage Lifter	Not harvested—poor sample
5	Blue Rose	This plot on porus soil—could not keep it wet.
65	Total.	

As a result of this and subsequent tests, Mr. Rowe decided that rice can be successfully grown there and that Lady Wright is the best variety for the latitude of the corn belt. This variety matures in a period of from 115 to 120 days; it has a vigorous upstanding straw and it is a long grained rice which commands a better price than the short grained varieties.

Later a short grained variety was tried; this was The Early Prolific; the yield was heavy but the inferior sample and lower price did not cause it to displace Lady Wright in the favor of Mr. Rowe or in that of his neighbors.

The trial above led Mr. Rowe and several of his neighbors to plant a total of 700 acres in rice the next year (1924) all of which was supplied with water by means of a plant installed by Mr. Rowe. In 1925 there was a total of 2100 acres which was increased to 3000 acres in 1926, all supplied with water by Rowe's pumping plant. Other neighbors cooperated to install other pumping plants after Rowe's initial and subsequent success, until there was, in 1926, a total of 10,000 acres of rice crop in that neighborhood. Four hundred acres of rice were raised on the river at Quincy, Ill., in 1926. Mr. J. Morton of The Morton Salt Company, has a large tract of land on the Illinois River near Canton, Ill., part of it being the drained lands of Thompson's Lake, some years ago well known as a duck hunter's paradise. The owner, after getting in touch with Alvin Rowe, seeded 210 acres of rice in 1925; this tract yielded 55 bu. per acre. Subsequent yields on this land are not at hand. Rice growing may now be said to have become an established industry in the corn belt latitudes of the middle west.

The Returns.

Mr. Rowe has had various yields—one field of 24 acres yielded 72 bu. per acre (rice weighs about 45 lbs. to the bushel). 100 acres yielded 7000 bus.; 9 acres of Jap (short grained variety) yielded 1130 bus. A field of 140 acres returned a gross sum of $22,000.00 in 1925. This rice graded No. 1 and No. 2 and sold at $1.74 per bushel, F. O. B. Elsberry.

The Preliminaries for Rice Growing.

The first steps in rice growing include leveling. An engineer is employed to run contour levels, a rod man works with him across the proposed rice field stopping with target at 100 ft. intervals. A man with team and plow follows the contour markings immediately behind the engineer and his assistant so that from 60 to 80 acres of river bottom land are leveled per day. The finished dykes which may be thrown up by the use of a small road grader or even a plow are from 10 inches to 24 inches high. On bottom lands, they are from 10 feet to 1,000 feet apart. The rise of each contour line above the lower is three inches. Water is pumped to the highest plot and when a given depth is secured the excess passes to the level below through a wooden distributing box and gate which prevents washing. These small levees do not seriously interfere with the use of the binder or tractor which cross them in field operations at the will of the operator.

Methods of Growing Rice.

The ground is plowed and seed bed prepared as for wheat. Seeding may begin about the same as for the planting of corn, i. e., May 1st to 10th. The seeding may be done by means of an end-gate broad cast seeder but a much more even stand will be obtained by using a wheat drill set to place the seed at a depth of two inches. The plants are allowed to reach a height of eight inches before flooding—the rice in this early stage stools out with 3 to 7 branches (as many as 67 stools coming from one rice plant have been counted). Each stalk produces from 170 to 200 grains of rice in the form of a panicle. After flooding is begun, water is kept at a depth of from two to four inches for a period of 90 to 100 days. The rule is 10 gals. of water per minute per acre. There should be a heavy clay subsoil which will prevent loss of water downward. Mr. Rowe's land is a heavy gumbo 15 feet thick. In Arkansas, rice is successfully raised on land having a hard pan subsoil. Mr. Rowe found that he was unable to pump water fast enough to irrigate certain of his lands having a sandy subsoil. Allowance for evaporation is necessary.

Pumping ceases ten days to two weeks before cutting.

Harvesting.

Various varieties of rice require different growing periods. The Lady Wright, chosen by Mr. Rowe, requires about 4 months. Sown about the middle of May, it was ripe about Sept. 15th; however, due to wet autumn, some of it was not harvested until the following January after which it threshed as a very fair sample. This fact shows one of the points of the commercial excellence of rice, viz.: its keeping qualities under adverse moisture condition such as prevailed in the fall of 1925, also in 1926.

Methods of Harvesting.

This grain is harvested by the use of a rice binder which is simply the wheat binder with certain adaptions. It is drawn by a tractor which has minor changes including extension lugs of 34 inches in length, filled wheels to keep the mud from crowding between the spokes and a power take-off (a revolving shaft furnishes the power from the tractor to drive the binder mechanism). One change in the binder is the use of an 8-foot platform joined to binding mechanism designed to care for the wheat furnished from a ten-foot platform. The binder head is speeded up to care for the very large quantities of long rice straw. Standard binder twines are used. A bundle carrier collects the sheaves which are set up into rather smaller shocks than is the practice in the case of wheat. Land which has been so recently flooded is, of course, soft below when the tractor is taken into the field. This is not reported as one of the troubles of harvest, however.

Threshing.

The regular grain separator is used with slight changes as in the screens, adjustment of concave, spike teeth, etc. However, Mr. Rowe greatly lowered the cost of threshing by adopting the practice of the Dakotas and Western Canada where the basket rack and drop feeder are used to save in number of men. Also, this keeps teams idle a much smaller proportion of the time. J. Russel Smith is authority for the statement that by the use of machinery, the American rice producer has a much lower unit cost of production than the Chinese with hand methods and a labor cost of 20 cents per day.

Rice Paddy.

The rice, as it leaves the thresher, is covered with a brown skin and this grain is known as paddy rice or paddy. It is difficult to remove this covering without the use of special machinery. The nearest rice mill containing such machinery is at Memphis, Tenn., where most of the Elsberry rice is sent, after being inspected by buyers who as representatives of southern rice mills make bids on the newly threshed crop. It is said that The Elsberry rice growers are contemplating the erection of a rice mill as a co-operative enterprise. The cost of the mill is said to be about $50,000.

Advantages of the North in Rice Production.

The advantages of the northern rice producing area are:

(1) A heavier yield; 30 bushels is a good average yield for in Louisiana and Texas the heads of southern rice plants average 6 inches in length; in the Elsberry district the average length is 12 inches.

(2) The southern planter is greatly troubled by red rice, very much like the wild oat of the northern wheat farmer; it is necessary for the southern rice grower to have his land remain without rice crop every second year and to mow or pasture the red rice which continues to grow through the mild winter. The growers in the Elsberry district have been careful to secure seed free from weeds, but should the plant get started it will be killed by frost. It is well known that plants are most successful in the belt of highest latitude in which they can be grown; as many plants and insect enemies are thereby eliminated.

(3) There is an increasing local demand for rice in the north, also a very limited acreage of land suitable for rice culture. (The realtor near the Mississippi River now checks his listings of bottom lands with the soil map to determine whether or not its sub soil will allow of rice culture.)

(4) There is less danger of overproduction in rice than of other crops because of the limited suitable area. (By raising this crop the acreage of wheat and corn, in which there is overproduction, will be cut down.)

RELATIVE HUMIDITY AND FOREST FIRES.

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Fire is a natural phenomenon and is controlled by natural factors. Various factors of the atmosphere such as air pressure, temperature, precipitation, wind movements, electrical condition, and humidity, all have been studied in their relation to forest fires. Other factors, however, have also been considered. For example, experiments have shown that fires will burn more rapidly uphill than on level ground.[1] Man himself has been a factor of major significance. He is both actively and passively concerned. The environmental factors are beyond his control. But he is responsible for most of the fires, and he frequently adjusts himself differently in areas which have been burned over than in similar unburned regions.

Of the meteorological elements mentioned above, some are especially significant in their relation to forest fires. Winds, high temperature, and low humidity, either singly or in combination, are particularly effective in producing a high fire hazard.[2] The element, however, that seems to claim the distinction of being the controlling factor in fire hazard is relative humidity. Temperature and wind only accentuate the influence of low relative humidity. "Humidity is now recognized as being of special significance in connection with the starting and spread of forest fires. It is being studied perhaps more intensively than any other factor connected with the problem."[3]

Relation of relative humidity to temperature, winds, and precipitation.—Owing to the fact that temperature, winds, and precipitation are important factors in connection with the fire hazard, they are frequently given a place of undue importance.

Experiments have shown that high temperatures may occur during periods of high relative humidity and con-

[1]Osborne, W. B. Jr., 1925. "Primary factors governing action of forest fires." The Timberman. Vol. 26. 190.

[2]Norquist, C. E. 1925. "Weather conditions as related to fire control." The Timberman. 26:132.

[3]Calvert, E. B. 1925. "Weather forecasting as an aid in preventing and controlling forest fires. Monthly Weather Review, 53:187.

sequently have no drying effect.[4] An extreme fire hazard, however, will exist during periods of low temperature if the humidity is low.[5] The common belief that high temperatures cause rapid evaporation is simply a result of the fact that we usually have a comparatively low relative humidity when temperatures are high. Occassionally, however, we have high temperatures and high relative humidity. Under such conditions the materials of the forest are not highly inflammable, and instead of evaporating may be actually absorbing moisture from the atmosphere. Of course, temperature is one of the components of relative humidity; but if we know the relative humidity we have already taken into account the effect of temperature.

It is a well established fact that strong winds may occur during periods of low as well as high relative humidity. Hence, a strong wind may actually extinguish a fire if it brings in air which contains much moisture. A strong wind, on the other hand, occuring during a period of low humidity causes the most serious combination of factors. "All of the great historic forest fires have occurred during periods of low relative humidity. In a few cases the wind was extremely high, but in the great majority of cases, the records show that the winds were not at all abnormal."[6]

The author has observed in northern Wisconsin (1) that forest fires would die down under increasing winds when those winds were carrying in moisture-laden air, and (2) that winds lose their velocity a short distance within a stand of heavy timber. The latter may be substantiated by experiments conducted at the Wind River Experiment Station. An anemometer operated for an entire season at the Wind River Station and located 200 yards inside of a dense stand of mature timber failed to show any wind velocities of over two miles an hour, although velocities of 15-20 were frequently recorded a short distance out in the adjacent burn.[7]

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[4]Hofmann, J. V. and Osborne, Wm. B. Jr.: Relative Humidity and Forest Fires, 5.

[5]*Ibid*, 25:57.

[6]Hofmann, J. V.: "Relative Humidity and forest fire prevention and control." The Timberman, 25:56.

[7]Osborne, W. B. Jr. "Primary factors governing action of forest fires." The Timberman, 26:190.

Fire fighters have observed that under similar burning conditions a fire located on a steep slope and without wind will burn uphill nearly as fast as a similar fire would spread on level ground and backed by a moderately strong wind. This fact becomes extremely significant in areas where the timber is located on steep slopes.[8]

Winds, however, are of great significance to foresters in some parts of the country. Mr. Beals, of the weather bureau service, found that there was a definite relationship between easterly winds and forest fires west of the Cascade Mountains. Furthermore, he has studied the ways in which forest fires may create their own winds.[9]

A deficiency of rainfall does not necessarily indicate a fire hazard, but a forest area is well protected as long as the relative humidity remains high. The effect of rains is not a lasting one. Rains make the forest safe from fire for only a short time if periods of low humidity occur. "The ameliorating effects of precipitation are immediate and, within limits, are directly proportional to the amount. However, the dampening effects of light rains on forest materials under the shelter of heavy stands of timber are negligible and the effect of moderately heavy rainfall is somewhat dissipated in a surprisingly short time."[10]

The relation of relative humidity to fire fuels.—The relationship of relative humidity to forest fires is established through the fire fuels or forest litter upon which the fire feeds. Forest fuels consist of needles, branches, twigs, windfalls, bits of bark, moss, grass, etc.

Relative humidity, being the percentage of saturation of the air, largely governs its absorbing and evaporating power. Consequently the relative humidity is the greatest factor in controlling the moisture content of those forest fuels which are directly exposed to the air and determines the degree of their inflammability. The inflammability of the forest fire materials is the most important factor which controls the fire hazard. Since relative humidity has a direct bearing on the degree of inflammability, and since

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[8] *Ibid.*

[9] Beals, E. A. "The value of weather forecasts in the problem of protecting forests from fire." Monthly Weather Review, 42:111-119.

[10] Norquest, C. E. "Weather conditions as related to fire control." The Timberman, 26:132.

this can be determined, a record of relative humidity therefore can be used as an indicator of the fire hazard.[11]

The inflammability point for the various fuels is not the same. Light fuels such as moss and dead weeds may be dry enough to ignite with a match; while twigs, duff, and branchwood are too wet to burn. Light fuels such as fern, firewood and pearly everlasting have shown very rapid changes in moisture content with changes in relative humidity. Thus where those materials occur in abundance, hourly and daily records are very significant. Records show that a period of humidity of 35 per cent or lower for only one day will cause a fire hazard in open areas of fern, firewood, pearly everlasting and other weeds and grasses in the early spring before these dead materials are covered by a new growth of weeds, grasses, and shrubs.[12]

In some areas the light fuels are the ones which deserve the most careful attention. C. S. Cawan says: "If the logging operator can get rid of the light material, such as twigs, needles, and splintered debris, on the ground, he has got rid of 90 per cent of his hazard, that is, the material which would readily light from the carelessly thrown cigarette, cigar, or match. The larger material does not readily ignite from a chance spark; it must be dried and set alight by the flame and heat from the smaller material or kindling before it becomes a source of danger."[13]

J. T. Gisborne has shown the importance of duff moisture content in the forest fire problem. He found that in most of the valuable timber of northern Idaho the top quarter to half-inch layer of duff exhibits the effects of weather elements as they affect dryness and inflammability in the forest. Top layer duff picks up or loses moisture about as the average important fuel in this type, and is itself one of the most important receivers and carriers of fire.[14]

Air-dry litter is marked by deliquescent, that is, it takes up moisture from the air, independently of precipitation. And even during the hot season it takes up from 5 to 6 per cent of its own air-dry weight every night. This ex-

[11]Hofmann, J. V. and Osborne, Wm. B. Jr. "Relative Humidity and Forest Fires. 1."

[12]Hofmann, J. V. and Osborne, Wm. B. Jr. "Relative Humidity and Forest Fires. 6."

[13]Cawan, C. S. "The loggers hazard in its relation to fire weather." The Timberman 26 No. 9:134.

[14]Gisborne, J. T. "The importance of duff moisture content in the forest fire problem." Journal of Forestry, 21:809.

plains to a very large extent the well-known fact that fires burn more slowly by night than by day.

Not only kind of forest material but amount as well should be taken into account when calculations of the danger point are made from relative humidity records. For example, in western Washington the hazardous point is reached when the relative humidity falls 35 or below, whereas in eastern Washington, the hazardous point is not reached until the relative humidity falls to 20 or below. The difference is explained by the fact that forest growth and underbrush are not as dense in the pine region of eastern Washington as in the fir region of western Washington. Hence there is much less inflammable debris present.[15]

Experimental evidence of the relationship of relative humidity to forest fires in various parts of the country.— The above records from Washington, indicate that the danger point varies from one part of the country to another, and variation is closely related to the kinds of forest materials which are found.

Studies conducted by the Wind River Forest Experiment Station on the effect of relative humidity on forest fires showed that fires did not spread when the relative humidity was above 60 per cent. That they spread very slowly and only in very favorable material when the relative humidity was between 50 and 60 per cent. When the humidity was between 40 and 50 per cent fires picked up, varying from a few running fires to fires that smoked up and did not spread. With a humidity of 30 to 40 per cent, fires gained some headway and some rapidly spreading fires occurred. A humidity below 30 per cent caused fires to spread beyond control. Crown fires occurred when the humidity dropped to 25 per cent or lower.[16]

In Connecticut, records of the number of fires per day for the years 1922, '23, and '24, show that there were less than ten fires per day when the relative humidity was between 60 and 70; about 15 per day when the relative humidity was between 50 and 60; and over 30 per day when the relative humidity was between 40 and 50 per cent.[17]

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[15]Cronemiller, L. P. "Relative humidity and forest fires." The Timberman, 26, no. 5:64.

[16]Hofmann, J. V. "Relative humidity and forest fire prevention." The Timberman, 25, No. 1:56-58.

[17]Moss, A. E. "Forest fires and weather." Journal of Forestry, May, 1926, 556.

In Idaho a study of the records in connection with 192 man-caused fires shows that 62 per cent of them occurred on days when the relative humidity had fallen to 20 or below, and 30 per cent of them when the humidity lay between 20 and 30 per cent. It therefore appears that the danger of fire from matches, cigars, and cigarette butts, is not high when the humidity remains above 30 per cent, is fairly high when the humitity is between 20 and 30 per cent, and is very high when the humidity falls below 20 per cent.[18]

Strikingly significant is the record kept of the great Berkeley fire. This fire destroyed over 50 square blocks of dwellings in the city of Berkeley, the seat of the University of California. At 5 o'clock on the 17th of September, 1923 there was a sudden rise of over 60 per cent in the relative humidity, and the fires in the city, which had seemed uncontrollable, were extinguished in a short time.[19]

Application of relative humidity records.—Thus far we have seen the importance which relative humidity possesses as a factor in relation to forest fires. It remains for us to note the more favorable adjustments which may be made to check the fire hazard.

Definite knowledge in regard to the inflammability of forest materials as indicated by the relative humidity of the present moment, is of inestimable value in all phases of protection and suppression work.

The following adjustments to meet the fire situation are worthy of careful consideration.

1. The smoldering fires must be put out immediately, while they are small, when they can be handled at small expense and before conditions change.

2. Slash burning should be performed when the relative humidity is high, and all fires should be extinguished immediately when the relative humidity is low. Spring is the best time in which to dispose of slash, because the slash is dry enough to burn in the spring while the lower layers of duff still contain sufficient moisture to protect the

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[18]Norquest, C. E. "Weather conditions as related to fire control." The Timberman, 26, No. 9:132.

[19]Alexander, Geo. W. "Weather and the Berkeley fire." Monthly Weather Review, 51:464.

seed that is stored in the forest floor from the heat of the fire.

3. Burn first near rights-of-way. It is not the custom or habit of human beings to wander through a slash area when they can follow an old trail. This means that the danger from fire, which is largely a man-caused one, is not very far from the rights-of-way or trails.

4. Burn the light materials. If the logging operator can get rid of the light material, such as twigs, needles and splintered debris, he has got rid of 90 per cent of his hazard, that is, the material which would readily light from a carelessly thrown cigarette, cigar, or match. The larger material does not readily ignite from a chance spark.

5. A greater number of hygro-thermographs, hygrographs, or sling psychrometers should be distributed throughout the forest areas so that more careful records may be kept of relative humidity, the important factor in forest-fire control.

Bibliography.

(Relative Humidity and Forest Fires)

1. Alexander, Geo. W. 1923. Weather and the Berkeley fire. Monthly Weather Review 51: p. 464, September.
2. Alexander, Geo. W. 1923. Intensive studies of local conditions as an aid to forecasting fire weather. Monthly Weather Review 51: pp. 561-563. November.
3. Bates, Carlos G. 1923. Evaporation as a simple index to weather conditions. Monthly Weather Review 51: p. 571. November.
4. Beals, E. A. 1914. The value of weather forecasts in the problem of protecting forests from fire. Monthly Weather Review (1913) 42: pp. 111-119. Illus.
5. Beals, E. A. 1916. Droughts and hot weather. Monthly Weather Review 44: p. 135. March, 1916.
6. Beals, E. A. 1916. How the weather bureau can help. Monthly Weather Review 44: p. 139. March.
7. Bigelow, F. H. 1910. Studies on the phenomena of the evaporation of water over lakes and reservoirs. Monthly Weather Review 38: pp. 1133-1135.

8. Calvert, E. B. 1925. Weather forecasting as an aid in preventing and controlling forest fires. Monthly Weather Review 53: p. 187. May.

9. Cowan, C. S. 1925. The loggers hazard in its relation to fire weather. The Timberman 26: No. 9, p. 134. July.

10. Cronemiller, L. F. 1925. Relative humidity and forest fires. The Timberman 26: No. 5, p. 64.

11. Dague, C. I. 1925. The fire weather service in Oregon. The Timberman, 26: No. 9, p. 142. July.

12. Gisborne, J. T. 1923. The importance of duff moisture content in the forest fire problem. Journal of Forestry 21: pp. 807-809.

13. Hofmann, J. V. 1923. Relative Humidity and forest fire prevention. The Timberman, Vol. 25, No. 1, p. 56-58. November, 1923.

14. Hofmann, J. V. 1924. Putting fire weather to work. The Timberman, 25: No. 7, pp. 65-66. May.

15. Hofmann, J. V. and Osborne, W. B., Ja. 1923. Relative humidity and forest fires. U. S. D. A. Circ. (unnumbered) 11p. Illus.

16. Joy, Geo. C. 1924. Prediction of fire hazard days. The Timberman, 25, No. 7, p. 94. May.

17. Joy, Geo. C. 1925. Meteorology in forest fire control. The Timberman, 26: No. 9, p. 130. July.

18. Kummel, J. F. 1925. Relative water holding capacity of sphagnum and tree moss. Journal Forestry. February, 1925.

19. Moss, A. E. 1926. Forest fires and weather. Journal Forestry, May, 1926. p. 555.

20. Norquest, C. E. 1925. Weather conditions as related to fire control. The Timberman, 26: No. 9, p. 132. July.

21. Osborne, W. B. Jr. 1925. Primary factors governing action of forest fires. The Timberman, 26: No. 10, p. 190. August.

22. Pearson, G. A. 1923. Seasonal distribution of rainfall as related to forest fires in Arizona and New Mexico. Journal Forestry. 1922. p. 776.

23. Show, S. B. 1919. Climate and forest fires in N. California. Journal of Forestry, 1919. 17: pp. 965-979.

24. Show, S. B. 1921. Physical control of fires. Journal of Forestry, 19: p. 917.

25. Simpson, ———. 1925. Static as an indicator of fire weather. The Timberman, 26: No. 9, p. 138.

STRATIFIED INDIAN MOUNDS IN WILL COUNTY.

GEORGE LANGFORD, JOLIET, ILLINOIS.

Fifteen miles from Joliet above the mouth of the Illinois River are certain Indian mounds which I have excavated extensively, resulting in discoveries of considerable importance. The mounds rest upon a limestone gravel deposit near the edge of a bluff 30 feet above and overlooking the Des Plaines River. This elevated position with gravel affording perfect drainage beneath was an ideal condition for the preservation of human relics buried below ground level, although those higher up in the mound body were less favored because of the dark soil there.

The mounds are distinctly stratified, a most unusual occurrence. Their construction broadly resembles a chocolate cake, the earth layers being separated from each other by thin dark seams of mineralized vegetable matter with grass and weeds at the surface taking the place of frosting. The thin seams denote long pauses in construction, each being an old surface where grass and weeds once grew just as they now grow on top. Each layer between the seams contains bones and relics of men distinct racially and in their civilizations except near the surface where various types intermingled. Short, Meso and Long-heads are terms indicating ratio of greatest skull width or breadth above the ears, to greatest skull length measured from forehead to back of neck. This skull ratio or cephalic index as it is called, is much used by anthropologists in determining important racial characteristics. The Middle layer is given over exclusively to a rather small and feeble people with short heads. Further down are even smaller people, also short-headed. Still lower in gravel are larger mesos, or ones with heads of medium length. Beneath them so well concealed in gravel that my discovery of them was purely accidental, are rather small Long-heads. The sequence of Short-heads overlying Meso-heads and the latter superimposed upon Long-heads without mixture of types is a condition we would hardly expect to find except in isolated races or those dating back into ancient times. As far as I know such a sequence has not heretofore been found in Indian

Mounds of this country. That the people of the locality I have explored are all Indians from the oldest to the most recent, I am fully convinced; at least various peculiarities of the skulls, teeth and limb-bones are similar to those commonly met with in our various so-called Indian races. The civilization of the Middle layer is one that experts would diagnose at first glance as Stone Age Iroquoian. This is interesting if true, in that it throws light upon the origin of tribes that went to make up the powerful Iroquoian confederacy which played such a prominent part in our French and Indian and Revolutionary Wars. Their civilization before white men appeared has been traced no farther west than Ohio.

Except upon the surface where colonial silver ornaments have been picked up, the deposit from top to bottom is purely aboriginal without a single suggestion of the White Man's influence. The people of the Upper layer were mostly Short-heads with a few Mesos. Although the men were as a rule powerfully built, I found no tall ones, the greatest stature observed being about 5 feet 6 inches and most of them shorter. They lay in various postures, some upon their backs, others upon their sides with legs straight or slightly bent. Cobblestones occasionally covered head and shoulders. None had been burned or mutilated. Relics were few—flint and chert arrowpoints 1½ to 2 inches long and notched or stemmed at the base. None had pipes and I could find no sign of cloth, wood, fruit or grain, although I searched diligently.

Going deeper in the Upper Level, skeletons and relics became more abundant. The men were powerful but taller, 5 feet 8 inches and under. There were Short-heads, Mesos and Long-heads as above and they lay in the same postures but they had more things with them, small clay pots, tools and ornaments of bone and copper and many bones of animals, among which were the dog, evidently domesticated. The pots, squat and bowl-shaped with short constricted necks, were unglazed and without decoration engraved or painted. In each one was an uncarved river clam-shell used as a spoon. The copper objects consisted of several small hatchet-heads rudely hammered to shape. The bone-work showed many polished pieces and much variation in form. Some were large pins, others neck pendants used for per-

sonal adornment. Games were represented by deer ankle bones probably dice, cut and bored elk toe bones and polished stone tablets with bone cylinders. This latter game, which may be likened to marbles or tiddle-de-winks with the stone tablet as "shooter" seems to have been a popular one with the young ladies, for three of them had each a set placed beneath her head. Long draw knives, probably used for dressing hides and small notched pegs, possibly needles, represented domestic implements. For the hunt and war, long sharp pointed cones bored for sockets served as arrowpoints. A single bone fish-hook without barb or eyelet but otherwise similar to our modern steel hook, was evidence enough that these people ate fish and caught them as we do. They may also have used nets or traps, but nothing remained to so indicate. A small spade-like tool of elkhorn, a round polished stone and an antler point lying together beneath one skull strongly suggest pottery manufacture, the spade-like tool being used to shape and pat the clay outside against the round stone held against the inside, the antler-point being an engraving tool for surface decoration after the pot, still in a plastic state, had been brought to the desired shape. Other odd-shaped bone pieces are more problematical although the fact that they were cut from soft rather than hard material would have made them useless as tools.

The Upper layer rested upon a thin black seam of carbonized vegetable matter. Passing down through this into the Middle layer I encountered 18 inches of brown pebbly soil resting upon a 6 inch earth and ash-layer, the latter being sandwiched in between two more thin black seams. The Middle burials lay closely beneath the Ash Layer and below ground level. All of the skeletons were Short-heads, physically feeble and none over 5 feet 4 inches tall. They lay upon their backs generally with face to the east. They were big-eyed, broad-nosed and long faced with wide prominent cheeks, projecting teeth and weak lower jaws. Some had very wide heads with narrow temples. Male adults were few, women and children predominating. Many young women were accompanied by tiny infants. One had two beside her. Everywhere in the mound I found signs of care and reverence for the dead. Clay pots containing bits of bone and clam-shell spoons were placed beside each head,

the latter adorned with a meager ornament of bone, copper or shell and an ash-bed covering all. In eleven cases, all of children, one hand was within the accompanying pot, evidently placed there by the mother to make sure that her child would find the food close by. None of the males had pots, lying only with a bundle of flint arrowpoints, a lance-head and stone tomahawk beside them. These weapons were all mounted on wooden shafts as attested in one instance where the wood had left long dark marks on the gravel. No sign of cloth, grain or pipes as yet. Apparently the people of this Middle layer were meat, fish and clam eaters and did not smoke. The earth over them was full of charcoal, clam-shells and the bones of birds, turtles, fishes and animals. I found many unshaped bones under human skulls with stone and bone implements placed there intentionally. Deer, elk, puma, bear, beaver, mink, wildcat, otter, raccoon, goose, wild turkey and many others were represented. I could find no remains of dogs, common in the layer above. The Short-heads of the Middle Layer are the ones previously referred to as possible forerunners of the great Iroquoian Confederacy. The main characteristic of their civilization classed elsewhere as Iroquoian is the use of the small triangular arrowpoint without base notches or stem. This occurred in the Middle layer to the exclusion of other forms. These arrowpoints are made of white chert; keen-edged, sharp-pointed and very thin and small. No other kind has better penetration, a most important consideration for ones compelled to offset physical inferiority with superior weapons so that a stiff bow and powerful arm were not absolutely essential for piercing power. This selection of efficient tools for war and chase was also true of the stone hatchets or tomahawks, which were made long to gain weight and slender to increase penetration. They are keen-edged and highly polished.

The only other stone tools found are hammerstones and bones for smoothing wooden arrowshafts. The former were nothing more than large pebbles of quartz or chert held in the bare hand and used on one side then the other until a blunt edge finally resulted. No grooved stone axes appeared; no gorgets, plummets, banner-stones, pierced tablets or other showy pieces classed as positively non-Iroquoian. The second type of stone tool in the mounds is a

roughly shaped sandstone block with a deep groove on one surface. Fitting this groove to the wood and moving the stone to and fro, the aboriginal archer could make his arrowshafts smoother and straighter. The absence of stone mortars and pestles for grinding grain were in keeping with the lack of agricultural tools and anything else suggesting vegetarianism.

The bone culture of the Middle Layer is crude, the pins and ornaments being only roughly shaped. Copper pieces consist of discs worn at the ears and bead necklaces. Clam-shells were cut and pierced to wear as pendants or the thick parts carved into beads for wear around the neck. Shell spoons found in pots were cut to form stub handles or notched with saw-teeth on their lower margins. The pottery is quite artistic both in shape and decoration. Some vessels had loop handles or rim lugs and most of them bore parallel rows of meanders, festoons or diagonals with dots or dashes, engraved upon the outside surface before drying. I call these "antler-point" pots, believing that the engraving was done with the tips of deer horns, common in the mound. The pottery decoration is quite pleasing artistically in spite of its extreme simplicity. It is the only form of art observed. Faces and figures of men or beasts are entirely lacking. In preparing his clay-paste, the potter incorporated a large percentage of rock or clam-shell, pulverizing and mixing this in to assist shrinkage and prevent cracking as the vessel dried in the sun or near a slow fire. Most of those found with skeletons were thin-walled; only 1/16 inch in places, although fragments in the camp-refuse thrown upon the mound are much thicker—¼ to ½ inches—also more coarsely made. The finer type appeared to be more a funeral urn than the coarser, though more durable, was less artistic and intended solely for use.

Although peaceful interments, some skeletons bore marks of battle. One male skull had a small triangular chert arrowpoint embedded in the left temple. Another with round hole in the forehead and a bone arrowpoint close by suggests a second violent death. In one female adult skull was a chisel-like stone hatchet with blade driven into the face. A young woman with a child had a small triangular chert arrow-point in the left shoulder-blade and a bone arrowpoint in the forearm. There were other similar

cases. Disease affecting the limb bones was often evident. Many legs and arms had been broken and healed in life usually resulting in deformity. One long bone of a left hand carried a small triangular chert arrowpoint embedded in the base. The point had entered the palm of hand and protruded at the back of wrist. It was apparent that the one thus stricken had vainly endeavored to remove the missile which was broken at point and base, but it was stuck fast and so remained in life with the bone enlarging around it.

At the foot of the Middle layer were a few very small people without any relics whatsoever and lying in sprawling postures. They were Short-heads. The greatest male adult stature observed was not over 5 feet.

The Lower layer burials in gravel from 3 to 4 feet below ground level were Meso-heads overyling Long-heads, and strangely enough, this relative position was maintained in every instance, the Long-head always being undermost. The Meso-heads were fairly tall and robust, the greatest male adult height being 5 feet 8½ inches. These were narrow-nosed, long-faced men with big teeth and massive jaws. All lay upon their sides, usually the left with knees drawn up. None had pots or relics of any kind, not even clam-shells, charcoal or animal bones. The gravel about them was absolutely bare. The Long-heads were somewhat smaller than the Mesos. Their bones are hard and heavy and well-preserved. The skeletons lay in crouching postures on the left side, face to the north. They had no pots, nor implements of bone or copper. Two adults had worn chipped flints near the heads; too crudely shaped, however, to be recognizable as tools. One old man wore a shell tube at his throat. A woman was accompanied by two notched shells resting upon her face. It is interesting to note that the three shell ornaments are not freshwater but marine species. They once lived in the ocean. This last female burial was quite elaborate, relatively considered. She lay upon her left side like one asleep. An infant was pressed closely to her side. Her head rested upon a mosaic of limestone pebbles in the center of which was an oblong granite block veneered with a seam of metamorphic rock—all unfabricated but carefully selected and arranged. Like other deep Long-head burials, this one was literally encased

in a gravel vault which under the closest scrutiny could not be detected from above. I came upon one quite by accident and so after that I always dug deeply with the hope of discovering another. I found eight at various times, all crouching Long-heads in concealed graves. Who they were and where they came from is a matter for experts to determine; and there are other problems of interest. The crouching posture adhered to by the Mesos and Long-heads with faces looking northward was too prevalent to have been a chance occurrence. It has been suggested that these were northern people possibly Eskimos, but this is mere conjecture. The entire absence of pipes, grain, fruit-pits, nut-shells and agricultural implements throughout the mound implies that all of the people were meat-eaters and did not smoke. A kernel of grain, one plum-stone and a single fragment of stone or clay pipe would have proved the contrary, but I could find none, although tiny objects such as teeth of mice and copper plate beads 1/16 inch in diameter were readily recognized.[1] My only assistant in the work of excavation was Albert Tennik of Joliet. Business gave us no time for digging except on Sundays and holidays and only 80 days have been spent upon the site, although the work is continuing and with remarkable success. Two mounds only 60 feet in diameter and 6 feet high contained more than 300 human skeletons, 70 clay pots and numerous relics of polished stone, chipped flint, bone, copper and shell. The ground around the mounds has yielded an additional 100 skeletons and other relics. It is not my province here to discuss the structural features of the mounds and other details explaining on what grounds my conclusions as to the stratification of the mounds is based. A longer and more technical description with illustrations will soon be published in "The American Anthropologist."

[1]Since this article was written, I have spent a season of excavating the pits around the mounds and these correlating with the mounds have disclosed several stone pipes and caches of charred corn with some acorns, showing the pit people, therefore the mound people of the upper and middle levels did smoke and had vegetable food.

PLEISTOCENE AND RECENT HISTORY OF ALEXIS QUADRANGLE AND VICINITY.[1]

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Introduction.

This paper summarizes the results of Pleistocene studies made in connection with the geologic mapping of the Alexis quadrangle, Mercer and Warren counties, Illinois, for the Illinois State Geological Survey, and discusses a significant Pleistocene section in the Milan quadrangle, which has been described by Savage and Udden.[2] The section is redescribed here, because it shows two gumbotils, and the original description preceded the introduction of the term gumbotil into Pleistocene literature. The writer wishes to acknowledge the assistance given by Dr. M. M. Leighton, who visited these sections with him, and made many helpful suggestions in interpreting them.

The Pleistocene deposits exposed in the Alexis area belong to the Kansan and Illinoian glacial stages and the Yarmouth, Sangamon, and Peorian interglacial stages.

Kansan Glacial Stage.

The oldest known Pleistocene deposit in the Alexis quadrangle is till of the Kansan glacial stage. Where exposed, it is usually a black or dark blue gray, highly carbonaceous and calcareous till. It contains more large boulders than the overlying Illinoian till. One granite boulder 8 feet in diameter was found in the Kansan till of the Alexis quadrangle. The drift is believed to belong to the Keewatin center of glaciation, as no jasper conglomerate or other rocks characteristic of the Labrador center have been discovered in it. The direction of ice advance was from the west or northwest.

Yarmouth Interglacial Stage.

The Yarmouth interglacial stage is represented by soil and gumbotil formed from the Kansan till where it was

[1]Published by the courtesy of the Chief, Illinois State Geological Survey.

[2]Savage, T. E., and Udden, J. A., Geology and mineral resources of the Edgington and Milan quadrangles: Illinois State Geological Survey, Bull. 38, pp. 164-165, 1922.

exposed to weathering on poorly drained upland surfaces. This gumbotil is ashy gray in color. A freshly broken chunk shows a pitted surface. This gumbotil is best developed in an exposure in the Milan quadrangle, 1½ miles northwest of Cable, in a number of gullies on the north side of a creek valley.[3]

Pleistocene section measured from outcrops and augur borings, ¼ mile east of the middle of the west line of sec. 8, T. 15 N., R. 1 W.

	Thickness		Depth	
	Ft.	In.	Ft.	In.
12. Loess, Grassy slope at top, not gullied (Peorian)	11	0	11	0
11. Loess, calcareous (Peorian)	7	6	18	6
10. Gumbotil, grayish brown (Illinoian)	1	6	20	0
9. Till, calcareous, brownish above, blue gray below (Illinoian)	16	6	36	6
8. Sand, containing some pebbles with diameters as large as ¼ inch, grading to fine sand without pebbles at base	2	10	39	4
7. Silt, sandy, light gray, grading to fine sand near base, calcareous	1	8	41	0
6. Sand and silt, white, noncalcareous		6	41	6
5. Silt, white, calcareous		6	42	0
4. Sand, brownish, noncalcareous		3	42	3
3. Soil, black, noncalcareous (Yarmouth)	1	9	44	0
2. Gumbotil, gray, with minute quartz and chert pebbles (Kansan)	2	6	46	6
1. Till, dark blue gray, strongly calcareous (Kansan). Reported 30 feet by Savage and Udden	4 exposed		50	6

Kansan gumbotil is also exposed at two or three localities in the Alexis quadrangle below the Illinoian till, but the relations are not so clear as they are in the section described above.

Another type of Yarmouth sediment occurs in the southern part of the Alexis quadrangle. In a number of recently cut gullies on the south side of Henderson Creek, a thick bed of reddish cross-bedded sand overlies the Kansan drift and underlies the Illinoian drift. The most typical section of these beds is described on page 256.

The reddish color and noncalcareous character of the sand (No. 3 of table on page 256) suggest that it was exposed to weathering with frequent wetting and drying for a long time before the Illinoian till covered it. It may have been an outwash deposit from the receding Kansan ice-sheet. Many farm wells obtain water from sands and gravels below the Illinoian till. Stumps and logs are reported in farm well drillings at depths of 30 to 40 feet.

[3]Savage, T. E., and Udden, J. A., *op. cit.*, p. 167.

Pleistocene section in a gully on the south side of Henderson Creek, about 700 feet southwest of the NE. cor. sec. 10, T. 12 N., R. 3 W.

	Thickness		Depth	
	Ft.	In.	Ft.	In.
11. Soil (Recent)	1	9	1	9
10. Loess, brown to buff, leached (Peorian)	10	6	12	3
9. Loess, gray to buff, calcareous (Peorian)	8	9	21	0
8. Silt, sandy, brown to chocolate colored, noncalcareous, with humus and carbonized plant traces (Late Sangamon)	2	9	23	9
7. Gumbotil, brownish, with pitted surfaces, and a few chert pebbles (Illinoian)	1	10	25	7
6. Till, rusty colored, very sandy, reacting slightly with acid (Illinoian)	15	0	40	7
5. Boulder concentrate at base of till (Illinoian)	1	0	41	7
4. Silt, sandy, light yellow, cross-bedded, noncalcareous (Illinoian or Yarmouth)	1	0	42	7
3. Sand, reddish, cross-bedded, irregularly color banded (Yarmouth)	18	0	60	7
2. Till, light blue gray, leached, (not typical gumbotil) with slight gravel concentrate at surface (Kansan)	4	6	65	1
1. Till, black or dark blue gray, highly calcareous, weathering whitish, as a result of efflorescence of calcium salts (Kansan)	20 exposed		85	1

It is believed that the Yarmouth sands and soils and the Kansan gumbotil are much more extensive in this region than their exposures indicate. The amount of dissection during Yarmouth time is not clearly indicated, but it is believed that the larger stream valleys were developed then.

Illinoian Glacial Stage.

Outwash deposits from the advancing Illinoian ice-sheet seem to be shown in the calcareous silts, sands, and pebble beds (Nos. 5-8 in the section near Cable, in the Milan quadrangle, described above). Illinoian till covered the entire area of the Alexis quadrangle. Proof that this till belongs to the Labrador center of glaciation is found in occasional pebbles of jasper conglomerate which are probably from the Lorraine quartzite, northeast of Lake Huron. Many large blocks of coralline limestone containing colonies of *Chaetetes milleporaceus* are prsent in the till at two localities. This limestone is believed to be the Lonsdale limestone (Pennsylvanian) which is exposed near Illinois River from Peoria north to La Salle. Fragments of Burlington limestone and chert are found in the Illinoian till in the southern part of the quadrangle. The direction of movement of the Illinoian glacier, as determined from these constituents, must have been from the

east or southeast. Thus the direction of Illinoian ice invasion was directly opposite from that of the Kansan invasion.

The Illinoian till is blue gray where unweathered. It is less calcareous and carbonaceous than the Kansan till, although perhaps only locally. It is not certain to what extent the valleys, which were excavated in Yarmouth time, were filled with Illinoian till. It appears that the larger valleys were only partly filled with till, because the depth and width of valleys in which Sangamon deposits accumulated seem too large to be the result of Sangamon erosion.

Sangamon Interglacial Stage.

Following the recession of the Illinoian glacier a gumbotil was formed from the Illinoian till on flat or poorly drained upland surfaces, which is similar to the gumbotil on the Kansan till. Above the Illinoian gumbotil there is usually a layer of loess or loess-like silt which, in the Alexis quadrangle, is not known to exceed three feet in thickness. It is noncalcareous, and in many places contains small carbonized traces of plant material. It is probably a late Sangamon deposit, equivalent in age to the Sangamon loess described by Leighton.[4] It is not thick enough in the Alexis quadrangle to show a calcareous zone. A black soil in many places overlies the Sangamon loess-like silt or the Illinoian gumbotil.

The amount of erosion which was accomplished during Sangamon time was sufficient to strip all Illinoian till from the surface in some places. In a gully exposure near the northwest cor. SE. ¼ NE. ¼ sec. 12, T. 12 N., R. 3 W., the late Sangamon loess-like silt rests on the Illinoian till, and a few feet away on the Yarmouth reddish sands. In a cut bank along the edge of a low terrace along the south side of Pope Creek the section described on page 258 is exposed:

No. 1 of this section is believed to be Sangamon, overlaid by Peorian loess. The position of this old soil at the present water level shows that no actual deepening of the valley of this stream has taken place since Sangamon

[4] Leighton, M. M., The Farm Creek exposure near Peoria, Illinois—a type Pleistocene section: Illinois State Acad. Sci. Trans., vol. 18, pp. 402-404, 1925.

time. Other terrace remnants of similar form are common along the larger streams, and the loess has been found to form the terrace material in one other place. This shows that the levels of the larger streams of the area in late Sangamon time were generally as low as they are at present.

Pleistocene section of a cut bank on the south side of Pope Creek in the NW. ¼ sec. 4, T. 13 N., R. 3 W.

	Thickness		Depth	
	Ft.	In.	Ft.	In.
6. Loess or loess-like silt, yellowish, soft	2	0	2	0
5. Loess or clay, yellowish brown, non-calcareous	3	0	5	0
4. Clay, slightly sandy, becoming more sandy toward base	3	6	8	6
3. Sand, brownish at top, yellowish at base, well stratified	3	6	12	0
2. Loess, blue gray, highly calcareous (Peorian)	4	0	16	0
1. Soil, black, with no pebbles, to level of Pope Creek (Sangamon)	3	0	19	0

Iowan Glacial and Peorian Interglacial Stages.

No deposits of Iowan age are known in this region unless the main loess deposition started here in late Iowan time. If the thin Sangamon loess was calcareous when deposited, it seems to have been completely leached before the deposition of the overlying calcareous Peorian loess. If the Sangamon loess formerly covered the entire surface it was eroded from many of the slopes before the Peorian loess was deposited.

Loess of late Iowan or Peorian age covered the uplands, slopes, and valley plains of the main streams and their larger tributaries. It rests on the Sangamon loess, on the eroded surface of the Illinoian till, on Yarmouth sands, and on the Pennsylvanian and Mississippian strata which form the bed rock of this area. The loess varies from 6 feet or less to 20 feet in thickness. Where it is thicker than 8 feet there is an upper, buff colored, noncalcareous zone and a lower gray calcareous zone. Fossils of air-breathing gastropods were collected in the calcareous zone of the loess at three localities. The section of a terrace along Pope Creek described above shows stratified sands and clays 7 feet in thickness between calcareous loess below and noncalcareous loess or loess-like silt above. This suggests that the valley was flooded during the time of loess deposition and an alternation of fluviatile and eolian deposits resulted.

Wisconsin Glacial Stage and Recent Time.

No deposits which can be definitely ascribed to the Wisconsin glacial stage are present in this area. As loess deposits are found on the Bloomington moraine of the Wisconsin glacier in the vicinity of Peoria and elsewhere, a part of the loess of the Alexis area may be post-Wisconsin in age.

The larger streams meander in a series of small curves which are mainly restricted to the valley plain. Actively eroded cut banks are few along the larger streams. The valley plains show a series of large meander curves not related to the present meandering of the streams. This is believed to represent a period of active valley widening on the part of these streams before the Peorian loess deposition overloaded the valleys with debris. The fact that considerable remnants of these loess-covered terraces are still preserved along four of the five large streams of the area shows that these streams have not renewed active valley widening since the deposition of the Peorian loess.

The smaller streams in areas of cleared forest or cultivated slopes have trenched below their alluvial plains, which are preserved as terraces. The greatest amount of trenching is seen in those streams which have cut into the soft Yarmouth sands. This renewed erosion is probably the result of deforestation by man and cultivation of some of the steeper slopes.

Summary.

The Pleistocene and recent events in the Alexis region may be summarized as follows:

1. Kansan. Deposition of black, carbonaceous, very calcareous, bouldery till, probably from the Keewatin center.

2. Yarmouth. A very long interglacial epoch; development of a gray gumbotil from the till on poorly drained upland surfaces; formation of a black humus soil; deposition and oxidation of sands and silts; erosion of present main valleys nearly to their present size and depth.

3. Illinoian. Deposition of calcareous sands and silts in advance of the Illinoian glacier; deposition of blue cal-

careous stony till from the Labrador center, the direction of ice movement locally being from the east or southeast; partial filling of Yarmouth valleys with till.

4. Sangamon. Formation of brownish gray gumbotil and black soil on poorly drained surfaces; deepening of valleys of major streams at least to present depth; deposition of loess or loess-like silt in late Sangamon; beginning of leaching of this loess.

5. Iowan. Minor amount of leaching and some erosion on steeper slopes.

6. Peorian. Deposition of loess on uplands, slopes, and valley plains.

7. Wisconsin and recent. Leaching of part of Peorian loess; erosion of loess from smaller valleys and partial erosion from larger valleys, the remnants of Peorian valley plains forming terraces; recent renewal of erosion in smaller valleys, resulting from deforestation and cultivation of steeper slopes.

KARST TOPOGRAPHY AND SANITARY ENGINEERING AT ALTON, ILL.*

J. E. LAMAR, ILLINOIS STATE GEOLOGICAL SURVEY

In 1926, the City of Alton had a rapidly growing subdivision so located topographically that it was impossible to connect it with any of the existing city sewers without the expenditure of a considerable sum of money for the construction of a pumping station, tunnel or siphon. Therefore, inasmuch as the subdivision is located on the margin of an area of Karst or sink hole topography, it was proposed to dispose of the sewage by running it into a conveniently located sink which was at the time carrying off the surface drainage of the area. The Division of Sanitary Engineering of the State Department of Public Health raised the question whether or not the sewage discharged into this sink would enter Mississippi River above the city water supply intake, located about one-half mile south of the sink (Figure 1). The Illinois Geological Survey was called into consultation by the Division of Sanitary Engineering and this paper describes how the probable point of discharge was determined and the factors involved in the determination.

Factors Influencing Sub-surface Drainage Character of Rock Formations.

The rock formation involved in the region under consideration are the basal Ste. Genevieve and the Upper St. Louis limestones. The Ste. Genevieve is for the most part a pure limestone, locally oolitic. The St. Louis consists of thin, medium and thick beds of limestone some of which are very pure, others very argillaceous. In particular, a bed about 12 inches thick lying beneath a brown layer about 18 inches thick which in turn underlies the conglomeratic beds of the upper St. Louis, is highly argillaceous and in the bluffs about a mile and a half above the business district of Alton is responsible for numerous springs and seeps, as well as a rather extensive development of underground aque-

*Courtesy of the Chief, Illinois State Geological Survey.

ducts which descend to the general level of this bed irrespective of its elevation above the River.

Dip of the Rock Strata.

The dip of the limestone exposed in the river bluff has a great variation due to extremely local warpings, but in general is thought to be from 1 to 2 degrees, approximately S. 20° E.

Jointing.

In the area under consideration there are two principal and rather pronounced sets of joints, one trending about N. 60° E., the other N. 45° W. Of these the former is the most important in influencing sub-surface drainage, for by far the greater number of observable underground water channels trend approximately in the direction of this set of joints.

The Sinks.

The sinks vary in size from relatively large depressions about 300 feet in diameter at the rim and 60 to 80 feet in depth, to small ones of a few tens of feet in diameter and of proportionately shallow depth. Many of the sinks show limestone in their funnels and a few are the termini of small surface drains.

Conclusions Concerning Underground Drainage.

From a study of field evidence the following conclusions are thought warranted, and thought to apply to the sinks of the region:

(1) That the water draining into the limestone sinks descends through enlarged crevices and joints in the rock, moving principally downward until it reaches a layer of limestone which, because of its argillaceous or siliceous character, is less previous, and less soluble than the rock generally.

(2) That joints in these argillaceous beds tend to become clogged by materials, residual from the solution of the calcium carbonate from the rock and by settlings from the descending water whose movement may be partly or wholly impeded by the argillaceous beds.

(3) That the water moves laterally along these less soluble beds until it encounters crevices or joints which have not been closed and permit further downward descent.

(4) That the water entering sinks other than those immediate to the river bluff, flows in rather well-developed, mature sub-surface drainage systems.

(5) That the sinks immediate to the river bluff probably drain toward the bluff and such water as they collect issues through the caverns in the bluff.

(6) That the age of a given sink relative to others in the same region and rock formation is generally indicated by its size, and that the larger and deeper sinks are the older.

(7) That the alignment of the older sinks indicates the route of the oldest underground water channels and that these are probably the course of the major sub-surface drainage.

Determination of Underground Drainage.

With the foregoing points in mind the elevations of the bottom of the largest sinks throughout the area were contoured.[1] The resulting map (fig. 1) shows an alignment of older sinks which suggest that water entering the proposed disposal sink probably takes a southeasterly course, as indicated by the arrows in Figure 1, for about 700 feet. This course is possibly induced by the N. 45° W. joint system. Then, the underground drainage turns almost due south to the sink with an elevation of 120 feet. From this point the direction of flow is problematical because of the lack of elevations on sink bottoms. Either the N. 45° W. set of joints was most effective in influencing the course of the drainage and it went southeast to the Grand Avenue Creek system, itself an enlarged and united series of sinks, or else the effect of the major system of joints, the N. 60° E. set, with offsets in the course of the drainage due to the N. 45° W. joints, should result in the discharge of the water from the spring at A.

With these two potential points of discharge in mind, fluorescein was introduced into the stream of water entering the disposal sink. The dye was introduced at 3:30 P. M.

[1]The elevations of the bottoms of the sinks were taken from a topographic map kindly lent the author by Mr. J. E. Schwaab, City Engineer of the City of Alton.

and had not appeared in either of the potential discharges by 6:00 P. M. The following morning, however, spring A was flowing green water. The color persisted for about 200 feet out into Mississippi River. Examination of other springs along the river bluff in the suspected discharge area failed to reveal the discharge of dye-colored water from any other springs or seeps.

Conclusions.

The phenomena described suggest that at least in some regions of limestone sinks, it is possible to determine the general direction of the flow of underground water from contours drawn on the bottoms of the major sinks of the region, coupled with data on the jointing of the area and its effect on sub-surface drainage.

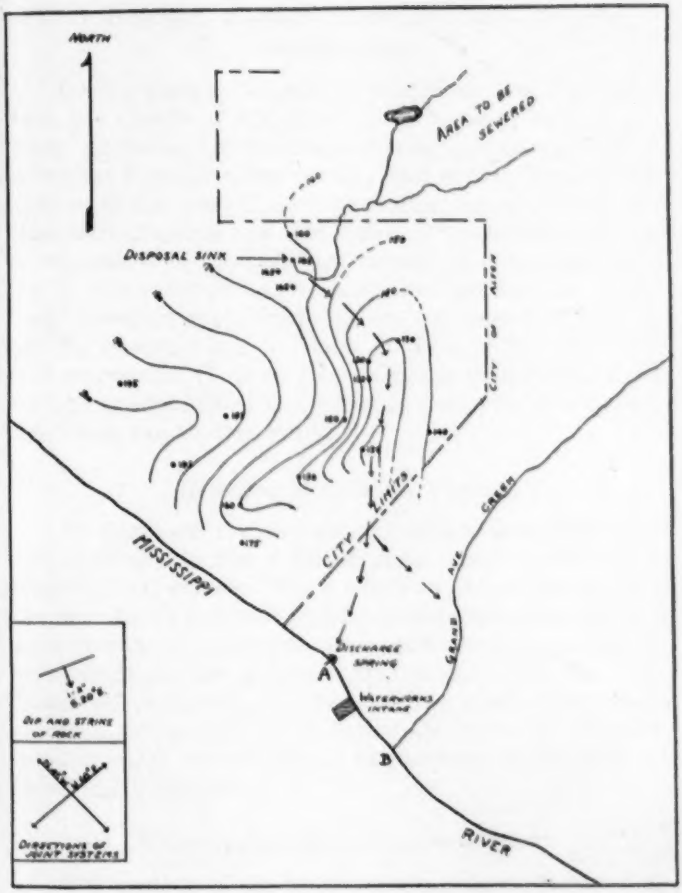
NORTH
AREA TO BE SEWERED
DISPOSAL SINK
CITY LIMITS
MISSISSIPPI
CITY
DISCHARGE SPRING
WATERWORKS INTAKE
A
B
RIVER
DIP AND STRIKE OF ROCK
DIRECTIONS OF JOINT SYSTEMS

FIG. 1.

PRE-PENNSYLVANIAN SURFACE WEST OF THE DUQUOIN ANTICLINE.*

L. G. HENBEST, ILLINOIS STATE GEOLOGICAL SURVEY.

Introduction.

During some stratigraphic studies on the Pennsylvanian, the results of which are to be included in a general report on the coal of the State, several interesting features of the pre-Pennsylvanian surface west of the Duquoin anticline were discovered. Several profiles, based on well records, were drawn across this region from west to east (one is reproduced in fig. 1). They showed that the contour of the Mississippian-Pennsylvanian unconformity, the depositional structure of the Pottsville and Carbondale formations, and the geographical, lithologic changes within the Pottsville correspond. This correspondence is so significant that the paleogeography of the region in Pottsville and Carbondale times can be determined.

Selection of a Datum Plane.

To eliminate the post-Pennsylvanian deformations, it was necessary to find a datum plane which represents an original, level surface. No. 6 coal was chosen because it is the most easily followed horizon in the Pennsylvanian, it is wide spread, its formation was conditioned by a state of quietude in geologic processes that is unique for the "Coal Measures" of Illinois, and its deposition marked the climax of those geologic processes during the Pottsville and Carbondale which worked toward an extension of the seas and the filling of the basins.

Mississippian-Pennsylvanian Contact.

The contour of the pre-Pennsylvanian surface was delineated by measurements from the datum plane, or No. 6 coal, to the Mississippian-Pennsylvanian contact. Figure 1 is a profile, based on well logs, extending from Millstadt to the Duquoin anticline at Centralia which represents some of these measurements. The vertical scale is 100 feet to the

*Courtesy of the Chief, State Geological Survey.

inch and the horizontal scale is 4 miles to the inch. The straight line at the top is the horizon of No. 6 coal and the bent line at the bottom represents the unconformable contact between the Mississippian and the Pennsylvanian.

The records above the Carbondale and below the Pottsville are omitted.

In figures 1 and 2 the divergence of the lines representing the datum plane and the pre-Pennsylvanian surface is conspicuous. In the vicinity of Millstadt, in St. Clair County, the interval between the top of No. 6 coal and the top of the Mississippian is from 10 feet to about 50 feet. Eastward, to the Clinton County line, the interval increases to about 150 feet, but between this county line and Trenton (Clinton County) the interval increases much more rapidly than elsewhere, i. e. from 150 feet to more than 350 feet. From Trenton eastward to the Duquoin anticline the interval increases less rapidly. Other profiles and well records not exhibited here show that this same general profile of the pre-Pennsylvanian surface is continuous from Madison County south to Coulterville, Randolph County. It is especially interesting that the escarpment near Trenton (figs. 1 and 2) extends almost due south toward Coulterville. It is called the Trenton-Coulterville escarpment in this paper.

Depositional Structure of the Pottsville and Carbondale Formations.

The correspondence between the topography of the pre-Pennsylvanian surface and the depositional structure of the Pottsville and Carbondale formations is significant.

A basin extends eastward from the brink of the Trenton-Coulterville escarpment. Its lowermost portion is filled with Pottsville sediments. The Carbondale formation overlaps the Pottsville and extends westward toward St. Louis; thus filling the rest of the basin below No. 6 coal.

Insofar as specific horizons in the Pottsville can be followed, they appear to thin out westward and to be overlapped by the strata above. If this is true, the thinning out is due more to conditions of deposition than to stages of widespread erosion after deposition, although intraformational unconformities probably are common in the Pottsville. The most that can be said at this time about the

changing thickness of the Carbondale formation is that horizons far apart vertically in the basin converge toward the west. The critical point in determining the causes of this convergence is the correlation of the coal below No. 6 which occurs along the margin of the Carbondale basin at Millstadt and at other places farther north. The correlation of this coal is uncertain, but it is No. 5 coal apparently. In general, then, the thinning of the Pottsville and Carbondale formations westward is due to a series of overlaps which indicates that marine invasions progressed toward the St. Louis region. The greatest overlap is that of the Carbondale over the Pottsville.

Lithologic Differences Within the Pottsville.

The lithology of the Pottsville has considerable bearing in determining the character of the pre-Pennsylvanian surface. Figure 3 is a diagrammatic representation of lithologic changes in the Pottsville formation. In Saline County, quartz pebble conglomerates are restricted to the lower Pottsville, but in western Williamson County and in Jackson County larger quartz pebbles have been found and they are not restricted to the lower Pottsville. The upper Pottsville in Saline County contains at least four marine limestones, and one of these limestones—the Curlew—is rather pure except for the presence of chert, and contains a fauna of large branchiopods, corals, and numerous Fusulinella and other Foraminifera, thus indicating a relatively quiet sea during its formation. In Jackson County, one lenticular limestone is reported from the upper Pottsville; whereas surveys northwest of this place, indicate that no limestones exist in the Pottsville at the outcrops. So the Pottsville takes on a distinct shoreward facies toward the northwest as would be expected from the contour of the pre-Pennsylvanian basin and the consequent depositional structure of the middle and lower Pennsylvanian.

Conclusions.

It appears from the evidence brought out that the pre-Pennsylvanian surface originally consisted of an upland area in the west half and a basin in the east half of this region and that the Trenton-Coulterville escarpment repre-

sents the western margin of the basin. After the filling of this basin by Pottsville sediments the strand line moved westward as a result of a general lowering and extension of the basin, and the Carbondale formation was deposited in the broader basin.

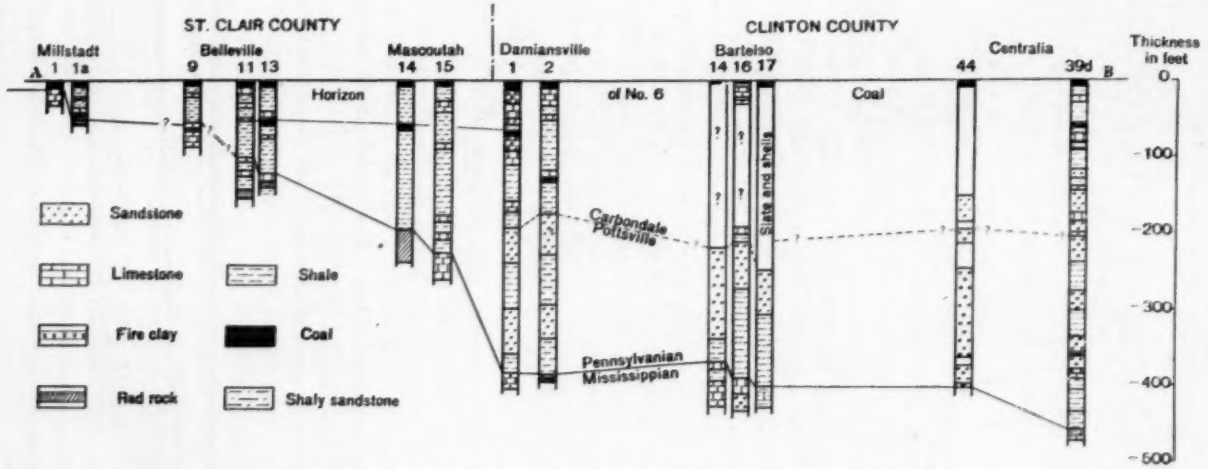

Fig. 1.—Profile showing the thickening of the Carbondale and Pottsville formations eastward. (The numbers at the top of the logs correspond to locations on the isopachous map, Fig. 2).

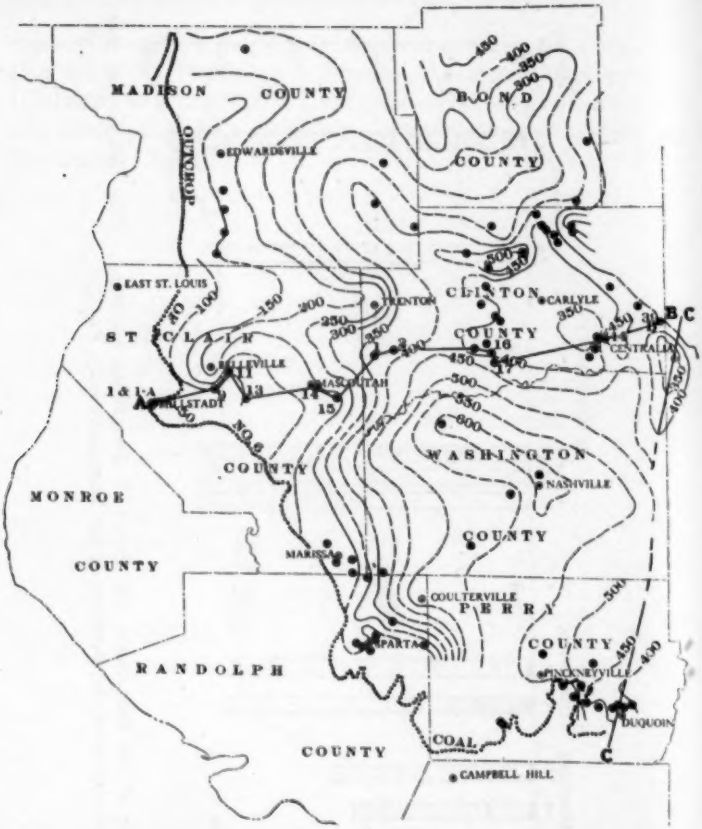

Fig. 2.—Isopachous Contour Map. The figures on the contours refer to the distance in feet from the horizon of No. 6 coal to the pre-Pennsylvanian surface. The line A-B gives the location of the profile in Fig. 1; and C-C the axis of the Duquoin anticline.

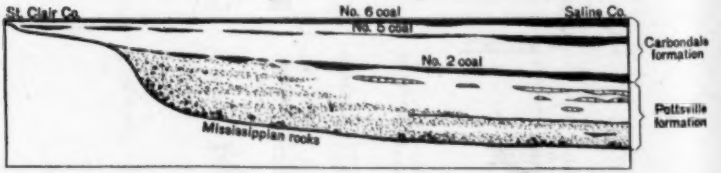

Fig. 3.—Diagram to represent horizontal lithologic changes in the Pottsville.

MOLLUSCAN LIFE OF THE LOESS DEPOSITS OF ILLINOIS.*

FRANK COLLINS BAKER, CURATOR, MUSEUM OF NATURAL HISTORY, UNIVERSITY OF ILLINOIS.

Introduction.

Since the work of Dr. B. Shimek on the mollusks of the Iowa loess deposits, little attention has been paid to the life of these very interesting strata. During the interval between Dr. Shimek's studies and the present time, the classification of mollusks has become much more refined and the limits of species and varieties have been more closely drawn, more weight being given to small variations than formerly. This so-called splitting of the species has become more and more necessary in the study of geological horizons for the purpose of recognition of different faunas of subordinate strata, and it is not strange that the more recent life of the Pleistocene should receive similar treatment, the result of which has been to recognize a number of apparently stable variations characteristic of some of the loess faunae, and which are different from the related forms living today. It has been stated that the land snail fauna of the loess deposits, and, indeed, of the whole Pleistocene, is practically like that living in the same area today. This statement has been found to need qualification, however, as the fauna of the Pleistocene is considerably different from that of the present time, especially as regards the State of Illinois. The writer has believed that a careful comparison of the Pleistocene with the recent fauna would show many species which differ more or less from their relatives living today, and the studies of the past ten years have shown that this supposition is correct, not only as regards the land fauna, but also of the fauna of the streams and lakes. That this should be so is not strange, for the covering of so large an area with a huge sheet of ice must necessarily have changed both climate and environment, and the fact that not all species responded to these changes again indicates that not all species have the same

*Contribution from the Museum of Natural History, Univ. of Ill., No. 47.

degree of plasticity in responding to changes of such a drastic character.

During the past six years the Illinois State Geological Survey, under the direction of Dr. M. M. Leighton, Chief, has been conducting surveys in various parts of the state, during which the superficial deposits have been carefully examined and their stratigraphy accurately worked out. This accuracy in the examination of field relations is of the utmost importance, for the value of deductions from fossil faunae rest absolutely on the accuracy of the work of the field geologists. The Survey has been fortunate in having available for its field studies such men as Dr. Paul MacClintock, Dr. Geo. Ekblaw, Dr. Benj. Cox, and Dr. H. R. Wanless, to all of whom as well as to Dr. Leighton, the writer's thanks are due. The present essay is of a cooperative character, between the Illinois Geological Survey and the Museum of Natural History of the University. The material described in two previous papers, collected by the Illinois Survey, should be consulted in connection with this paper and certain changes made in the species listed. This data is incorporated in the present paper (see Journ. Geol., XXX, pp. 43-62, 1922; The Nautilus, XXXIV, pp. 61-68, 1920). See also Baker, Life of the Pleistocene, Bull. Univ. Ill., XVII, No. 41, 1920. The material studied is in the research collection of the museum of natural history. For descriptions of new varieties see Nautilus, XL, p. 114, 1927.

Ecological and Climatic Considerations.

Of the 49 species and varieties listed in the table, 43 are strictly land mollusks, three live under moist conditions, bordering streams *(Carychium)* and three are amphibious, living in small, shallow streams, or, more frequently, on wet mud flats above water mark *(Galba, Pomatiopsis)*. As these genera now live in association with true land mollusks, which have migrated to the wet surface, it is not strange that they should be incorporated together in some loess deposits. In many cases the loess was probably deposited after the shallow wet area had become dry and the land mollusks wandered into this area seeking moisture. Only in a few cases are these aquatic forms associated with loess mollusks, the majority of land species living in open

woodlands or shrub-covered areas far above streams. This has been called upland loess, and the strata containing acquatic forms lowland loess, by the Iowa geologists and the distinction is well taken.

The land snail fauna found in loess deposits of the interglacial intervals indicates strongly that the animals were under climatic and environmental conditions which were different from those obtaining in Illinois at the present time. Of the 49 species and varieties listed in this paper 32 now live in Illinois, 10 are extinct, and 7 are now living in areas far removed from the state. Only 65 per cent now live in the same areas. Taking the fauna as a whole, it contains many species which now live in a drier and relatively more severe climate—Wisconsin, Michigan, Colorado, Nebraska, Utah, Arizona, etc. In the table the present location of the fossil species is indicated and it will be seen that they are, in some cases, far removed from Illinois. The near relatives of the extinct species also live far from the state area.

It has been affirmed that the fauna of the loess does not differ materially from that of today in the same area and that the climate must have been similar. But this could not have been so, judging by the nature of the fossils, as well as of the deposits, aeolian or wind-blown, fine dust. The present habitat of *Oreohelix cooperi* (relative of *Oreohelix iowensis*), *Gonyodiscus cockerelli* (relative of *Gonyodiscus shimekii*), *Sphyradium alticolum*, *Vertigo modesta*, and *Vallonia gracilicosta* conculsively prove that the conditions in Illinois when these species lived must have been similar to those under which these species live today—drier and relatively cooler. The associated species, for the most part, now live with these species, in the western areas and their association together in Illinois loess deposits is not strange.

Several varieties of common local species, now abundant in Illinois, differ more or less markedly in size or form from the typical form as known today, as *Polygyra profunda pleistocenica*, *P. multilineata altonensis*, *P. hirsuta yarmouthensis*, *P. monodon peoriensis*, *Succinea ovalis pleistocenica*, *S. grosvenori gelida*, and *Pomatiopsis scalaris*, thus stamping the fauna as under more rigorous con-

ditions than at the present time, these variations being, for the most part, smaller than the typical form living today. This local variation will become more apparent, even in other species, when more material from more widely-spread localities is critically examined.

Of the four typical loesses represented, the Peorian at present contains the greatest number of species, 34 or 76 per cent, followed by the Early Wisconsin with 25, or 51 per cent. The Yarmouth and Sangamon will show a larger percentage of species when more deposits are discovered in Illinois. In Iowa the number recorded is greater than in Illinois. It is of more than passing interest to note that most of the Peorian loesses are regarded as Early Peorian, and some of them were probably laid down very soon after the retreat of the ice, indicating dry conditions at a very early stage of the interval. In the case of the loess overlying the Bloomington moraine in Bureau County near Weyenet, there is an absence of weathering between the till and the overlying loess, indicating that the loess was deposited soon after the recession of the ice. The climate thus would be somewhat colder than that of today and, apparently, was somewhat drier, perhaps like that of portions of Nebraska and the Dakotas at the present time, or even Idaho and Montana, where wind-blown sand in the form of dunes is now being deposited.

The present paper is to be regarded as a report of progress on a restudy of loess fossils from a modern viewpoint of taxonomy, as well as a more careful discrimination of stratigraphy than has been made previously. Greater quantities of many species are needed for comparison than have been available so that range of variation may be more clearly known. In the present contribution no attention has been paid to previous records of loess mollusks, only that material coming directly under the writer's attention being considered available. Some of these older records need confirmation.

Stratigraphic Data for Deposits in Which Terrestrial Life Occurs.

These deposits include silts, old soils, loess, and sands. The material has been collected by members of the Geologi-

cal Survey during the past four or five years. The species included in each deposit are listed and an interpretation is made of the geologic horizon of the stratum in which the life occurs.

Locality: Clark Co., three miles southwest of Marshall, NW, NE. sec. 16, T. 10 N., R. 12 W. Section as below noted:

1. Silts (like loess) but containing abundant glacial stones scattered through the mass, with fossils throughout the whole section, calcareous throughout..... 40 ft.
2. Leached and weathered pre-Illinoian drift..... 10 ft.
3. Pre-Illinoian till and gravel, calcareous..... 10 ft.

Stratigraphic Horizon: Probably Yarmouth, but might be Aftonian.

Dr. MacClintock believes that the best explanation of this deposit (1) is that it is an overridden pre-Illinoian deposit picked up by the ice and transported some distance. While this hypothesis appears doubtful from some standpoints, it seems the best at present available. The mixing of land, fresh water, and amphibious life suggests such a condition.

Molluscan Life: From number 1 silts.

Polygyra monodon peoriensis
Polygyra hirsuta yarmouthensis
Helicodiscus paralellus
Strobilops virgo
Succinea ovalis pleistocenica
Carychium exiguum
Galba parva
Pomatiopsis scalaris
Hendersonia occulta
Pisidium species

Locality: Clark Co., Big Creek exposure, near locality above.

Material: Taken from the top of the pre-Illinoian interglacial soil and from the lower few feet of the overlying Illinoian till, evidently picked up from the interglacial material and incorporated in the basal portion of the till, which is also very silty (MacClintock).

Stratigraphic Horizon: The pre-Illinoian till appears from its distribution to have had a Labradorian source and so may well be of Nebraskan age. The interglacial deposit, therefore, may be either of Yarmouth or Aftonian age, or possibly both, if the Kansan drift is absent (MacClintock). The mixing of land and fresh water species may indicate transportation from original locality.

Mulluscan Life:

Polygyra monodon peoriensis
Helicodiscus paralellus
Vertigo ventricosa
Cochlicopa lubrica
Succinea ovalis pleistocenica
Hendersonia occulta
Carychium exile
Carychium exile canadense
Galba parva
Gyraulus altissimus

Locality: Bureau Co., sec. 35, SW ¼ NE ¼, T. 16 N., R. 10 E., near Depue (Dr. Leighton).

Material: A section from a spur near Depue Zinc Co., shows:

1. Wash from slopes above ..... 5 ft.
2. Stratified sand, few pebbles and few shells, layers perceptibly inclined to the east ..... 10 ft.
3. Coarse gravel ..... 1–2 ft.
4. Glacial till, probably Illinoian ..... 10+ ft.
5. Fossiliferous silt with color bands gray and rusty; few scattered pebbles, changes above to glacial till. To the east, the slope becomes gray, stratified, and softer ..... 5+ ft.
6. Sand with few scattered pebbles and fossils, pinkish yellow, some thin layers of pink silt, gives pink coating when washed down over sand. Few thin cemented fragments of sand about 1 in. thick in gully ..... 20 ft.

Stratigraphic Horizon: The fossiliferous silts are believed to be of Yarmouth age, the stratified sand of Sangamon age.

Molluscan Life:

Polygyra hirsuta yarmouthensis
Polygyra monodon peoriensis
Helicodiscus paralellus
Succinea ovalis pleistocenica
Succinea grosvenori gelida
Hendersonia occulta
Galba parva

Locality: Jackson Co., Campbell Hill Quandrangle; Sec. 36, T. 7 S., R. 6 W., SW. ¼ NE. ¼. (Dr. MacClintock).

Material: Exposure along road cut up side of hill. Valley here shows terraces at 460 ft. AT and loess and till show in terrace deposits.

1. Leached loess ..... 20–25 ft.
2. Leached pebbly drift, many striated stones ..... 3–4 ft.
4. Leached loess ..... 2 ft.
5. Loess, calcareous, irregular "kindchen," iran mottling and aspect of old loess, very dense, fossiliferous ..... 10 ft.

Stratigraphic Horizon: No. 5 is believed to be pre-Illinoian loess, probably Yarmouth. Fossils rare.

Molluscan Life:

Hendersonia occulta
Strobilops virgo.

Locality: Mercer Co., Sec. 9, T. 14 N., R. 3 W., Mercer Township. From hard road cut (Dr. H. R. Wanless).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Succinea grosvenori gelida
Succinea ovalis pleistocenica
Heicodiscus parelellus
Gonyodiscus shimekii
Sphyradium alticolum
Vertigo modesta
Hendersonia occulta
Galba parva

Locality: Mercer Co., Sec. 4, T. 14 N., R. 1 W. (Dr. Wanless).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Polygyra thyroides
Succinea ovalis pleistocenica
Succinea grosvenori gelida
Gonyodiscus shimekii
Vitrea hammonis
Vertigo ventricosa
Vertigo modesta
Hendersonia occulta
Cochlicopa lubrica, var.

Locality: Warren Co., Sec. 12, T. 12 N., R. 3 W. From gully (Dr. Wanless).

Material: Loess.

Stratigraphic Horizon: Probably Peorian.

Molluscan Life:

Succinea ovalis pleistocenica
Succinea grosvenori gelida
Gonyodiscus shimekii
Sphyradium alticolum
Vertigo modesta
Hendersonia occulta

Locality: Rock Island Co., Sec. 22, SE ¼ of NW ¼, T. 18 N., R. 1 E. (Dr. Leighton).

Material: Loess over soil and gumbo till, 35 feet from top of hill.

Stratigraphic Horizon: Early Peorian Loess.

Molluscan Life:

Succinea ovalis pleistocenica
Succinea grosvenori gelida
Gastrocopta tappaniana
Sphyradium alticolum
Helicodiscus paralellus

Locality: As above.

Material: Loess over gumbo till, 15 feet from top of hill.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Vertigo modesta *Succinea grosvenori gelida*

Locality: Whiteside Co., NE ¼ NE ¼ sec. 32, T. 22 N., R. 5 E.

Material: Yellow loess, road cut across and over spur 11 feet maximum depth, shows: 9½ feet yellow loess over 1½ feet gray loess, both fossiliferous and calcareous; yellow loess effervesces more violently than gray loess; no sharp line demarcates the two, for they are gradational within 1-12 inches. (Dr. M. M. Leighton).

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Vertigo modesta *Succinea grosvenori gelida*

Locality: Whiteside Co., sec. 23, T. 20 N., R. 3 E, near center (Dr. Leighton).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Succinea grosvenori gelida *Pisidium species*
Galba parva

This deposit appears to be laid down near water, because the Galba is common while the *Succinea* is represented only by several immature individuals. The Pisidium also indicates nearness to water.

Locality: Bureau Co., NW ¼ sec. 1, T. 15 N., R. 6 E. New highway cutoff through three ridges going upgrade (Dr. Leighton).

Material: In lowest ridge is exposed 15-18 feet of pebbly sand, yellow; in next ridge, red sand beneath gumbotill gray and sandy, leached, passing through fossiliferous loess; in highest ridge fossiliferous loess. Between gumbotill and overlying fossiliferous loess is about 10 feet of chocolate brown, loess-like silt with band of gray color, calcareous mostly in spots. Fossils from fossiliferous yellow loess.

Stratigraphic Horizon: Peorian.

Molluscan Life:

Succinea ovalis pleistocenica *Gonyodiscus shimekii*
Succinea grosvenori gelida

Locality: Lawrence Co., 2 ¾ miles N-NW of St. Francisville, SE ¼ SE ¼ sec. 6, T. 4 N., R. 11 E. (Dr. MacClintock).

Material: Road cut in NW corner of group of hills rising above Wabash River flats and entirely surrounded by flood plain deposits. Top of cut is 8-10 feet below the highest elevation of the rather flat-topped hills. Road cut shows; from top to bottom:

1. Loess, leached, reddish buff ..... 3–4 ft.
2. Loess, calcareous, light yellowish buff ..... 4 ft.
3. Sand, calcareous ..... 1 ft.
4. Loess, calcareous, fossiliferous, containing abundant 'kindchen', gray drab, iron-mottled and concentrically stained ..... 4 ft.
5. Loess, leached, reddish buff more compact than that above .... 4 ft.
6. Till, weathered, leached and oxidized ..... 3½ ft.
7. Bed rock.

Stratigraphic Horizon: Dr. MacClintock suggests that No. 6 is Illinoian till, No. 5 Peorian loess, and No. 4 early Wisconsin loess. He also states that No. 5 might be Sangamon loess and No. 4 Peorian loess. The fossils do not include certain species which should be in Peorian loess and from this viewpoint the first interpretation would seem best.

Molluscan Life:

Polygyra hirsuta yarmouthensis
Strobilops virgo
Euconulus fulvus
Zonitoides minusculus
Hendersonia occulta

Locality: Madison Co., Collinsville bluffs (Dr. Leighton).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Hendersonia occulta
Pyramidula alternata
Gonyodiscus shimekii
Pupoides marginatus
Gastrocopta armifera
Polygyra appressa
Succinea retusa peoriensis
Succinea grosvenori gelida

Locality: Adams Co., Quincy, Vine and Second St. (Leighton and Cox coll.).

Material: Fossiliferous loess overlying till.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Gonyodiscus shimekii
Vertigo modesta
Hendersonia occulta

Locality: Adams Co., Municipal Quarry, NW ¼ NW ¼ sec. 26, T. 1 S., R. 9 W. (Leighton & Cox).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Hendersonia occulta
Polygyra monodon peoriensis
Polygyra appressa
Gonyodiscus shimekii
Sphyradium alticolum
Vertigo ventricosa
Vertigo modesta
Succinea ovalis pleistocenica
Succinea grosvenori gelida
Vallonia gracilicosta

Locality: Adams Co., Quincy, quarry near (south of) Curtis Creek, near bluff road on east side SE ¼ SW sec. 11, T. 2 S., R. 9 W. (Leighton & Cox).

Material: Loess from 15 feet above bed rock.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Hendersonia occulta
Polygyra monodon peoriensis
Polygyra fraterna
Helicodiscus paralellus
Gonyodiscus shimekii
Vertigo modesta
Succinea ovalis pleistocenica

Locality: Union Co., Alto Pass south of Textile Hollow (Dr. Ekblaw).

Material: Loess.

Stratigraphic Horizon: Probably Early Peorian.

Molluscan Life:

Polygyra profunda
Polygyra profunda near *pleistocenica*
Polygyra appressa
Polygyra tridentata
Polygyra fraterna
Succinea ovalis pleistocenica
Circinaria concava
Pyramidula solitaria
Pyramidula alternata
Gastrocopta armifera
Hendersonia occulta

The absence of such typical Peorian species as *Gonyodiscus shimekii, Sphyradium alticolum, Vallonia gracilicosta,* and *Succinea grosvenori gelida* suggests that this deposit may be younger than Peorian. These smaller fossils may have been overlooked, however, and the age may be true Peorian. The presence of a form of *Polygyra profunda,* described from Alton, gives a Peorian aspect to the deposit. All other species are present in the recent fauna.

Locality: Bureau Co., Buda Country Club, east bank Coal Creek. (Dr. MacClintock).

Material: Section of bank shows following strata:

1.	Soil and subsoil	2 ft.
2.	Pink till	7 ft.
3.	Laminated pink clays, calcareous	2 ft.
4.	Light buff-gray loess, fossiliferous	5 ft.
5.	Laminated (slightly fatty) gray clays	3⅔ ft.
6.	Dark gray loess, slightly calcareous, fossiliferous	4½ ft.
7.	Silt, dark gray, with small pebbles, slightly calcareous	1 ft.
8.	Clay, fatty, greenish to yellowish, leached and weathered	3½ ft.
9.	Silt, leached, with peat bands	2 ft.
10.	Alluvial coal (from underlying coal bed)	1 ft.
11.	Clay, no pebbles, leached	1½ ft.
12.	Till, calcareous, yellow to golden buff	2 ft.

Stratigraphic Horizon:

Dr. MacClintock interprets the section as 1, 2, Bloomington; 3, early Bloomington lake; 4-7, Peorian; 8-12 Iowan and Peorian. An alternative interpretation is that the lower may be Illinoian with Sangamon over it, and calcareous Peorian loess on the weathered Sangamon. Whichever one is correct makes the fossils Peorian in age.

Molluscan Life: The same species occur in both upper (4) and lower (6) loess.

Gonyodiscus shimekii
Polygyra monodon peoriensis
Succinea grosvenori gelida
Hendersonia occulta

Locality: Gallatin Co., Shawneetown hill, SW SW ¼ sec. 17, T. 9 S., R. 10 E. (Dr. MacClintock).

Material: Road cut on south side of hills exposes 20 feet of loess quite typical. Upper 3-5 feet leached, lower 15 feet calcareous and fossiliferous. This same loess covers the whole hill and no drift or rock was seen.

Stratigraphic Horizon: Dr. MacClintock does not venture an opinion concerning the age of the lower calcareous loess, but the life suggests Early Wisconsin, as it does not include typical Peorian fossils.

Molluscan Life:

Polygyra hirsuta yarmouthensis
Polygyra fraterna
Polygyra appressa
Pyramidula alternata
Gonyodiscus cronkhitei catskillensis
Hendersonia occulta
Vitrea hammonis
Helicodiscus paralellus
Strobilops labyrinthica
Vertigo gouldii
Gastrocopta armifera similis
Succinea grosvenori gelida

Locality: Gallatin Co., NE NW sec. 9, T. 9 S., R. 3 W., six miles west of Shawneetown (Dr. MacClintock).

Material: Loess.

Stratigraphic Horizon: Probably Early Wisconsin.

Molluscan Life:

Polygyra profunda
Polygyra appressa
Polygyra hirsuta yarmouthensis
Pyramidula alternata
Pyramidula solitaria
Hendersonia occulta
Galba parva

Locality: Bureau Co., Buda Quadrangle. (Dr. Mac Clintock)

Material: Railway cut exposing 15-20 feet of loess leached to depth of 6 feet. Gastropod fossils in a two-foot horizon about 9 feet from top of cut. Loess buff-drab in color and fairly dense in texture.

Stratigraphic Horizon: Post-Bloomington or Early Wisconsin.

Molluscan Life:

Vertigo modesta
Succinea grosvenori gelida
Vallonia gracilicosta

Locality: Bureau Co., Buda Quadrangle (Dr. Mac Clintock).

Material: Cut through gravelly phase of the Bloomington terminal moraine. Ten foot bank of Post-Bloomington loess, fossiliferous (MacClintock).

Stratigraphic Horizon: Early Wisconsin.

Molluscan Life:

Pupilla cf hebes
Vertigo modesta
Sphyradium alticolum
Succinea grosvenori gelida

Locality: Bureau Co., road cut east of Wyanet, east bank of West Bureau Creek, NE NW ¼ sec. 22, T. 16 N., R. 8 E. (Dr. MacClintock).

Material: Cut through Bloomington moraine shows:

1. Dark gray soil ..... ½–1 ft.
2. Bleached loess, yellow buff, with some gray mottling, limonite streak 1–2 in. thick near base ..... 7–8 ft.
3. Calcareous loess, yellow clay, with some ochre coloring in upper 2½ ft., mostly gray below with ferruginous pipes and stains up to 1 in. in diameter. Upper part of clay highly fossiliferous, lower part more compact ..... 6–7 ft.
4. Below loess calcareous till, pinkish yellow when dry, strong pink when wet, pebbly clay till with small sand lenses at top, limestone pebbles to top, some gray to dark shale.
   Till is dark gray at depth of 6–8 ft. below base of loess. On opposite side of valley the loess is underlain by 3–5 ft. sand and gravel.

Stratigraphic Horizon: Immediately post early Wisconsin.

Molluscan Life:

Polygyra pennsylvanica
Succinea grosvenori gelida
Vertiga modesta
Pupilla cf hebes
Sphyradium alticolum
Vallonia gracilicosta
Cochlicopa lubrica
Hendersonia occulta

Locality: Tazewell Co., SW NE ¼ sec. 27, T. 26 N., R. 4 W. (Dr. Leighton).

Material: Loess over Wisconsin till. Road cut near top of slope shows:

1. Gray soil ½–1 ft.
2. Maximum leached buff loess 3½ ft.
3. Maximum calcareous yellow fossiliferous loess 4½ ft.
4. Gravel with limestone pebbles, maximum 1 ft.
5. Banded silts for horrizontal distances of 20 ft., pinkish wavy 1 ft.
6. Pink calcareous till 6–7 ft.
7. Gray calcareous till, jointed, pinkish cast on surface 6+ ft.

Stratigraphic Horizon: Immediately post Early Wisconsin.

Molluscan Life:

Succinea grosvenori gelida
Gonyodiscus cronkheitii anthonyi
Vertigo modesta
Sphyradium alticolum

Locality: Henry Co., NW NE ¼ sec. 16, T. 17 N., R. 2 E. (Dr. Leighton).

Material: Gully exposure south side road shows:

Three feet fine sand with thin wavy bedding, yellow, overlain by ¾ ft. of very fine sand or silt mottled with limonite stains, overlain by ⅓ to ⅔ ft. of greenish gray fossiliferous silt, overlain by thin bedded pink gritless clay alternating with gray silt, overlain by ¾ ft. of grayish yellow fine sand, all calcareous.

Stratigraphic Horizon: Probably late Wisconsin.

Molluscan Life:

Gonyodiscus cronkhitei anthonyi
Succinea avara vermeta

Locality: Bureau Co., 3 ¼ miles south of Wyanet (Dr. MacClintock).

Material: Post Bloomington loess, a section showing:

Leached loess 3 ft.
Calcareous fossiliferous loess 8–9 ft.
Medium gravel ½ ft.
Pink calcareous till (Bloomington) 5–10 ft.

Stratigraphic Horizon: Contacts are all distinct with no weathering showing that loess was deposited soon after recession of the ice, i. e., Early post-Bloomington or very Early Wisconsin. At southeast side of cut the gravel is missing and the loess lies on the till. (MacClintock).

Molluscan Life:

Succinea grosvenori gelida
Vertigo modesta
Pupilla cf hebes

Systematic Discussion of Species.

Family HELICIDAE

Polygyra tridentata (Say)

Alto Pass, Union Co. Early Peorian. This is the small form of Indiana and Illinois, but rather more depressed than recent specimens.

Polygyra profunda (Say)

Alto Pass, Union Co. (Early Peorian); near Shawneetown (Early Wisconsin). The large, flattened form typical of the recent fauna. Among the Shawneetown lot there are several specimens resembling *pleistocenica*.

Polygyra profunda pleistocenica F. C. Baker

Near Alton (see Baker, 1920, p. 63). Occurs in loess of Sangamon age and in a concretionary basal horizon believed to be of Yarmouth age. This small form appears quite constant in the Pleistocene deposits examined.

Polygyra multilineata altonensis F. C. Baker

Near Alton, in loess of Sangamon age. This large variety of *multilineata* is at present known only from this locality and horizon.

Polygyra appressa (Say)

Near Alton (Sangamon); Alto Pass, Union Co., Adams Co., Quincy, and Collinsville bluffs, Madison Co. (Early Peorian); near Shawneetown, Gallatin Co. (Early Wisconsn). Specimens show some variation; the Alto Pass material is like that living today; Gallatin Co. specimens are rather larger (23 mm.) than recent forms from Illinois, and one specimen is without a parietal denticle and with a strong basal callus on lower lip; another specimen has a heavy parietal denticle almost like *palliata*. Specimens from Shawneetown Hill loess and from Collinsville have a distinct denticle on the upper part of the outer lip.

Polygyra pennsylvanica (Green)

Bureau Co., immediately Early Wisconsin loess. A single specimen is small and has a very low spire. Somewhat similar specimens occur living in Washington Co., Ill. Height 10; diameter 14 mm.

Polygyra thyroides (Say)

Mercer Co., Early Peorian loess. A single broken specimen apparently typical.

Polygyra hirsuta yarmouthensis F. C. Baker

Clark and Bureau counties (Yarmouth); near Alton Ill., and New Harmony, Ind. (Sangamon); Lawrence Co., St. Francisville (Peorian); Gallatin Co., Shawneetown (Early Wisconsin). The Pleistocene *hirsuta* are uniformly smaller and have a differently formed parietal tooth or lamina than the form now living in Illinois and Indiana.

Polygyra monodon peoriensis F. C. Baker

Clark and Bureau counties (Yarmouth); Adams and bureau counties (Peorian). The *monodon* vary greatly in the loess. The Adams County forms are uniformly smaller than the *monodon* of the recent fauna. All fossil forms differ sufficiently from recent forms for varietal distinction.

Polygyra fraterna (Say)

Union Co. and Adams Co. (Peorian); Shawneetown Hill loess (Early Wisconsin). The Pleistocene *fraterna* are about the same in size as the recent form of the species. A single specimen from Alto Pass has a very high spire as compared with recent forms. H. 6. 2; D. 9 mm. Not enough matarial is at hand to satisfactorily compare Pleistocene with recent forms of this species.

Oreohelix iowensis (Pilsbry)

This species is known from the loess of Iowa, in the Yarmouth, Sangamon, and Peorian intervals. It has been cited from Cass Co. (Sangamon), Whiteside Co. (Peorian), and Peoria (Peorian). It is apparently not abundant in Illinois (See Baker, 1922, p. 58).

Family CIRCINARIIDAE

Polita hammonis (Ström.)

Near Alton (Sangamon); Union Co., Alto Pass (Peorian). The fossil material is smaller, with a more depressed spire and a wider umbilicus than living specimens from Illinois. It is apparently not common as a fossil.

Family ZONITIDAE

Polita hammonis (Ström.)

Mercer Co. (Peorian); Shawneetown Hill (Early Wisconsin). It has also been reported from all intervals from

Aftonian to pre-recent (see Baker, Pleistocene, p. 389). The few specimens examined are similar to the recent forms. The record of *Vitrea wheatleyi* from Carroll Co. peat deposits (Baker, 1922, p. 58) is erroneous, the specimen being a form of *hammonis*.

Zonitoides arborea (Say)

Near Alton (Sangamon). Also reported from all intervals from Aftonian to recent (Baker, Pleistocene, p. 289). The Sangamon specimens are somewhat smaller than shells of the recent fauna. Not enough material is at hand for a satisfactory comparison of the fossil with the recent forms.

Euconulus fulvus (Müller)

Whiteside Co. (Peorian); St. Francisville, Lawrence Co. (Early Wisconsin). Reported from all intervals. The fossil specimens appear similar to the recent form.

Family ENDODONTIDAE

Anguispira alternata (Say)

Near Alton (Sangamon); Collinsville and Alto Pass (Peorian); Gallatin Co. (Early Wisconsin). The *alternata* from the Sangamon interval near Alton are uniformly smaller than shells from the recent fauna, as are also shells from the Peorian at Collinsville. The Alto Pass and Gallatin Co. specimens are larger and more like the recent form. Measurements of maximum diameter of the different forms are: Alton (Sangamon) 17 mm.; Collinsville (Peorian) 16 mm.; Alto Pass (Peorian) 20 mm.; Gallatin Co. (Early Wisconsin) 22 mm.; recent fauna from Illinois, 23-25 mm. It will be observed that the early forms from Sangamon and Peorian time are usually smaller than those from later time. More material is needed to establish this geological variation more definitely.

Anguispira solitaria (Say)

Alto Pass, Union Co. (Peorian); Gallatin Co. (Early Wisconsin). The specimens from Gallatin Co. average considerably larger than the usual size of the species as found in Illinois and Indiana, diameter 29 mm. Largest Illinois and Indiana specimen, 25 mm.

Gonyodiscus shimekii (Pilsbry)

Near Alton; Adams Co.; Collinsville bluffs; Whiteside, Mercer, Bureau, Warren counties, all Peorian interval.

This very striking species appears to be characteristic of the Peorian interval, scarcely a deposit of loess occurring that does not include this species. It has been reported from the Yarmouth interval in Iowa (see Baker, Pleistocene, pp. 254-256), but late studies by Alden and Leighton indicate that some of these may be referable to Peorian time (An. Rep., Iowa Geol. Surv., XXVI, 1917). In Illinois *shimekii* is not at present known in strata earlier than Peorian, nor is it found in later deposits. It appears to be a horizon marker for this interval. It is abundant in loess deposits of Iowa.

Gonyodiscus cronkitei anthonyi (Pilsbry)

Tazewell Co. (Early Wisconsin); Henry Co. (Late Wisconsin). The few specimens examined do not differ from the recent form. This species has been recorded from all of the interglacial intervals, but no material from Illinois earlier than Early Wisconsin has been seen (see Baker, Pleistocene, p. 389). Some of these records may have been based on the var. *catskillensis*.

Gonyodiscus cronkhitei catskillensis (Pilsbry)

Shawneetown Hill loess, probably Early Wisconsin. One specimen with high spire and angulated periphery appears referable to this form.

Helicodiscus paralellus (Say)

Clark and Bureau Co. (Yarmouth); near Alton (Sangamon); Adams, Rock Island, Mercer Co. (Peorian); Shawneetown Hill (Early Wisconsin). This almost monotypic species varies but little throughout the Pleistocene. The Yarmouth and Sangamon specimens are a trifle smaller and have a wider umbilicus than in the recent form, though the last feature varies much among the living representatives.

Sphyradium alticolum (Ingersoll)

Adams, Rock Island, Mercer, Warren Co. (Peorian); Bureau Co. (Early Wisconsin); Tazewell Co. (Late Wisconsin). In Iowa, this species has been recorded from Af-

tonian, Yarmouth, and Sangamon intervals. Most of the Pleistocene *Sphyradium* are probably referable to *alticolum*, which appears to be a species approaching extinction. It does not occur living in Illinois and is found only in the higher regions of the west (Utah, Colorado, Wyoming). *Sphyradium edentulum* is the species now living in Illinois. The *alticolum* from Post Wisconsin deposits is more like the living form in having the last whorl somewhat enlarged, causing a peculiar constriction behind this whorl. The shell is also somewhat narrower than the shell of the species as it occurs in the Peorian deposits (see Hanna, Proc. U. S. Nat. Mus., XLI, p. 373, 1911, for figures of all American species).

Family SUCCINEIDAE

Succinea ovalis pleistocenica (F. C. Baker)

Clark, Bureau Co. (Yarmouth); near Alton (Sangamon); near Alton, Madison Co., Mercer, Warren, Rock Island, Bureau, Adams, Peoria, Union Co. (Peorian). Also in Peorian loess at Freeport, Iowa. The Pleistocene form of this common recent species differs from the living form in having a longer spire and a rounder aperture. It appears most abundant in the Peorian interval and has not been seen from later deposits.

Succinea grosvenori gelida (F. C. Baker)

Bureau Co. (Yarmouth); Boone Co. (Sangamon); Mercer, Warren, Whiteside, Bureau, Boone, Rock Island, Adams, Carroll, Ogle, Stephenson, Madison Co. (Peorian); Bureau, Tazewell, Gallatin Co. (Early Wisconsin). This small *Succoinea* has been variously reported, many years ago as *verrilli*, and later as *grosvenori*, *vermeta*, and *avara*. It is apparently a variety of *grosvenori* peculiar to Pleistocene time. It is smaller and much more elongated than *grosvenori*. Baker's references (Journ. Geol., XXX, p. 43, et seq.) are all based upon this form. It extends throughout the series of intervals from Yarmouth to Early Wisconsin.

Succinea avara (Say)

Stephenson Co., in loess-like clay (Post-Wisconsin). A few specimens in this deposit are referred to *avara*, re-

sembling the small forms living in the Mackenzie River district of Canada. The largest specimen measures 5.5 mm. in length. Specimens from Henry Co. (Late Wisconsin) are probably referable to variety *vermeta* (Say)

Succinea retusa (Lea)

Whiteside Co. (Post-Wisconsin). A single, rather small specimen.

Succinea retusa decampi (Tryon?)

Bureau Co. (Yarmouth soil). The specimens referred to this variety are rather small, with strikingly flat-sided whorls and long spire. Two specimens measure, length 9.5 and 8 mm., diameter 5 and 4 mm.

Succinea retusa peoriensis (Wolf)

Madison Co., Collinsville bluffs (Peorian). Several specimens of a *Succinea* with wide shell is referred to this variety. Additional material is needed for a more satisfactory determination.

Family PUPILLIDAE

Strobilops virgo (Pilsbry)

Clark Co., Jackson Co. (Yarmouth). Lawrence Co. (Early Wisconsin). Typical but apparently rare. It has been reported from the Aftonian and Peorian intervals, but none has been personally examined (Baker, Pleistocene, p. 388).

Strobilops labyrinthica (Say)

Gallatin Co., Shawneetown Hill loess (Early Wisconsin). Typical form with one large, heavy parietal lamella emerging from aperture. This species has been reported from all intervals, but many of the records were probably founded on some one of the allied species. It probably occurs in other strata.

Pupoides marginatus (Say)

Madison Co., Collinsville (Peorian). The fossil form is slightly wider and has half a whorl less than the recent form of the species. Not enough material is at hand for confirming this variation as a stable geological form.

Gastrocopta armifera (Say)

Whiteside Co., Union Co., Madison Co. (Peorian). Typical for the most part, the Alto Pass (Union Co.) specimens being slightly narrower.

Gastrocopta armifera similis (Sterki)

Near Alton (Sangamon); Gallatin Co. (Early Wisconsin). The *armifera* from these deposits are noticeably narrower than the typical form, the columellar lamella is more pointed, there are but two palatal lamellae, and the parietal lamella is smaller than usual. This form is quite noticeably different from the wide typical form and appears to be the same as the recent *similis*.

Gastrocopta tapaniana (C. B. Adams)

Rock Island Co. (Peorian). One broken specimen is referred to this species.

Gastrocopta contracta (Say)

McHenry Co. (Late Wisconsin). Common and typical.

Pupilla cf hebes (Ancey)

Bureau Co. (Early Wisconsin); Whiteside Co. (Peorian). The *Pupilla* from the Illinois loess deposits is not *muscorum* but apparently *hebes*. They are of the same size (larger than *muscorum*), the aperture is completely edentate, and the lip lacks the heavy deposit of the recent species. There are seven whorls. A specimen from Whiteside Co., has the outer lip slightly thickened, but the Bureau Co. specimens are exactly like *hebes* from Arizona identified by Pilsbry. Measurements of two specimens are: L. 3.4 and 3.6 mm., diameter 1.7 and 1.9 mm. Arizona specimen L. 3. 6, D. 1. 8 mm. The aperture is shaped like *hebes*, *not* like *muscorum*. Additional material is needed to satisfactorily determine the range of variation of this pleistocene form. Dr. Pilsbry suggests that it may be local form of *muscorum*.

Vertigo ventricosa (Morse)

Clark Co. (Yarmouth); Adams Co., Mercer Co. (Peorian). The few specimens are apparently typical. Variety *elatior* sterki is reported from loess deposits at New Harmony, Indiana (probably Sangamon).

Vertigo gouldii (Binney)

Gallatin Co., Shawneetown Hill loess (Early Wisconsin). A specimen is referable to this species, but is rather more elongated than in living examples.

Vertigo modesta (Say)

Whiteside, Mercer, Warren, Rock Island, Adams Co. (Peorian); Bureau, Tazewell Co. (Early Wisconsin). This small land shell is very common in the loess of Iowa and Illinois and exhibits great variation in size and number of denticles in the aperture. In the Tazewell deposit the single specimen has only a small parietal tooth; specimens from Mercer Co. are the same. From Mercer and Whiteside counties specimens occur without a parietal tooth and these are similar to the form *parietalis* (Ancey) now living in the Rocky Mountain Region. The majority have four teeth as in the typical form. The size runs from 1.9 to 2.6 mm. in length. It has been recorded from the Yarmouth and Sangamon intervals, but specimens have been seen only from Peorian and later deposits. Some of the early records may have been based upon deposits now considered of later age. The record by Hershey (Amer. Journ. Sci., II, p. 324, 1896) appears to be referable to the Yarmouth interval, the clays underlying Illinoian till. It is recorded as *Pupilla blandi* (not of Morse), under which name *modesta* has been listed by Iowan geologists.

Family COCHLICOPIDAE

Cochlicopa lubrica (Müller)

Mercer Co. (Peorian); Bureau Co. (Early Wisconsin). The few specimens seen from these deposits are like the typical form now living.

Cochlicopa lubrica (Müller) Variety

Clark Co. (Yarmouth). A specimen from the Yarmouth soil differs from the living form in the size of the shell and in the small size of the aperture. It is also more slender. Length 5, diameter 2 mm.; aperture length 1.5, diameter 1.1 mm. The aperture is about 30 per cent of the length while in typical *lubrica* it is 35 to 40 per cent. Additional material is needed to determine the nature of the variation.

Family VALLONIIDAE

Vallonia gracilicosta (Reinhard)

Whiteside and Adams Co. (Peorian); Bureau Co. (Early Wisconsin). This is the common *Vallonia* of the loess. Fossil specimens are a trifle larger than specimens from Colorado, with less thickened reflected lip, and with very fine striae.

Family AURICULIDAE

Carychium exiguum (Say)

Clark Co., loessal silt (Yarmouth). Typical.

Carychium exile (H. C. Lea)

Clark Co., (Yarmouth soil). Typical.

Carychium exile canadense (Clapp)

Clark Co., (Yarmouth soil). Typical. The presence of the three forms of this genus, common at the present time in northern United States, is interesting, indicating that the deposit was formed in low, damp or wet ground. The specimens examined are typical of the forms living today. They have been recorded from all the intervals from Aftonian to Late Wisconsin.

Family LYMNAEIDAE

Galba parva (Lea)

Clark, Bureau Co. (Yarmouth soil and loessal silt); Carroll Co., blue silt (Peorian). Mercer Co., Whiteside Co. (Peorian loess). The fossil material shows some variation, especially in the length of the spire and the flatness of the inner lip. Some specimens resemble variety *sterkii* Baker. The recent form also varies greatly.

Family PLANORBIDAE

Gyraulus altissimus (F. C. Baker)

Clark Co. (Yarmouth soil). A single, immature specimen is referred to this species.

Family HELICINIDAE

Hendersonia occulta (Say)

Clark Co. (Yarmouth soil), Jackson Co., Bureau Co. (Yarmouth loess); Mercer, Warren, Adams, Madison,

Union, Bureau Co. (Peorian loess); Bureau, Gallatin, Lawrence Co. (Early Wisconsin); Near Alton (Sangamon loess). This small species is one of the most abundant mollusks in loess deposits and must have been widely and continuously distributed during the different interglacial intervals. Its modern descendant is widely distributed, but it is extremely local and the distribution markedly discontinuous. Specimens from several places in the Peorian and Early Wisconsin intervals are notably smaller than those from other places, indicating a size variation during Pleistocene time. It may be possible to establish a maximum and minimum size when more material has been examined. Yarmouth specimens are rather large, and measure 6 to 6.5 mm. in diameter; Sangamon specimens, 6-6.2 mm.; Peorian, 5.1 to 7 mm.; Early Wisconsin, 5.5 to 6.8 mm. The smallest specimens are from near Quincy, Adams Co., and these measure 5.1 to 5.6 mm. Another set from Gallatin Co., measure 5.5 to 6.1 mm. Not enough material is at hand to determine the variation among the recent examples of the species.

Family POMATIOPSIDAE

Pomatiopsis scalaris (F. C. Baker)

Clark Co. (Yarmouth, loessal silt). This newly described species has been found in Illinois only in this interval. In Indiana, the type locality, New Harmony, Posey Co., the loess is of considerable extent and thickness but its stratigraphic horizon has not been determined accurately. It has been considered Sangamon by Shimek (Baker, Peistocene, p. 306) but may equally well be Peorian. In Illinois, loess deposits in Lawrence Co. (St. Francisville) and Gallatin Co. (Shawneetown) are regarded as of Early Wisconsin age.

Pomatiopsis lapidaria (Say)

Stephenson Co., near Ridott (Late Wisconsin). These specimens are like the recent species. See Baker, Journ. Geol., XXX, p. 45.

True Freshwater Mollusca

Pisidium species

Clark Co. (loessal silt). A single valve of a large Pisidium occurred with land species. As *Galba, Pomatiopsis,*

and *Carychium*, species which habitually live in or near small streams or on mud flats, also occurred, it is highly probable that the single valve was washed onto a mud flat bordering a stream, as occurs frequently at the present time.

TABLE OF DISTRIBUTION OF LOESS LAND MOLLUSCA*

Species	Y	S	P	EW	LW	E	I	Ex	Present location.
Polygyra tridentata			x				x		
Polygyra profunda			x	x			x		
Polygyra p. pleistocenica	x	x	x			x			
Polygyra m. altonensis		x				x			
Polygyra appressa		x	x	x			x		
Polygyra pennsylvanica				x			x		
Polygyra thyroides			x				x		
Polygyra h. yarmouthensis	x	x	x	x		x			
Polygyra m. peoriensis	x	x	x			x			
Polygyra fraterna			x	x			x		
Oreohelix iowensis	x	x	x			x			
Circinaria concava		x	x				x		
Polita hammonis			x	x	x		x		
Euconulus fulvus			x	x			x		
Anguispira alternata			x	x	x		x		
Anguispira alternata, var		x	x					?	Minn., Wis.
Anguispira solitaria			x	x			x		
Gonyodiscus shimekii		?	x			x			
Gonyodiscus c. anthonyi				x	x		x		
Gonyodiscus c. catskillensis				x				x	Mich., Wis., Minn.
Helicodiscus paralellus	x	x	x	x	x		x		
Sphyradium alticolum			x	x	x			x	Utah, Col., Wyo.
Succinea pleistocenica	x	x	x			x			
Succinea g. gelida	x	x	x	x		x			
Succinea avara					x		x		
Succinea retusa					x		x		
Succinea r. decampi	x							x	Mich.
Succinea r. peoriensis			x				x		
Strobilops labyrinthica				x			x		
Strobilops virgo	x			x			x		
Pupoides marginatus			x				x		
Gastrodonta armifera			x				x		
Gastrodonta a. similis		x		x			x		
Gastrodonta contracta					x		x		
Gastrodonta tappaniana			x				x		
Pupilla cf hebes			x	x				x	N. Mex., Ariz., Nev., Utah, Col.
Vertigo ventricosa	x		x				x		
Vertigo modesta	x	x	x	x				x	Locally in Me., Vt., Ct., Rocky Mts.
Vertigo gouldii				x			x		
Cochlicopa lubrica			x	x	x		x		
Cochlicopa lubrica, var	x					x			
Vallonia gracilicosta		x	x	x				x	Mont., Col., Dakotas
Carychium exiguum	x	x	x	x	x		x		
Carychium exile	x	x	x	x	x		x		
Carychium cf canadense	x						x		
Galba parva	x		x		x		x		
Hendersonia occulta	x	x	x	x			x		
Pomatiopsis scalaris	x	x	x			x			
Pomatiopsis lapidaria					x		x		
Total distribution	18	19	34	25	13	10	32	7	

*Symbols in table: Y, Yarmouth; S, Sangamon; P, Peorian; Ew, Early Wisconsin; Lw, Late Wisconsin; E, extinct; I, living in Illinois today; Ex, exotic or living north or west of Illinois today.

OIL PROSPECTING IN WESTERN ILLINOIS ON THE BASIS OF THE STRUCTURE OF COAL BEDS.

ALFRED H. BELL, ILLINOIS STATE GEOLOGICAL SURVEY.

Introduction.

The most efficient and economical development of oil resources depends in part upon an understanding of the mode of origin and accumulation of oil pools. Oil is found in the interstices of porous strata, mainly sandstones and limestones; most sedimentary strata are not porous enough to contain oil that can be profitably extracted. Moreover, many sufficiently porous strata contain salt water or gas instead of oil. Two of the fundamental questions of petroleum geology are, first, when and where have the porous beds been formed; and, second, what conditions govern the filling of some with salt water and some with oil or gas?

The Anticlinal Theory.

One of the earliest generalizations concerning the occurrence of petroleum is known as the anticlinal theory. According to it, oil is found at the crests of anticlines, or up-bowings of the strata, and gas, oil and water have a definite succession in the porous stratum according to their respective specific gravities. The warpings of the strata may be shown on a map by contours which represent lines of equal elevation of some stratum called the "key horizon" which passes over the fold.

Relation of Oil and Gas Fields to Structure in Southwestern Illinois.

The known occurrences of oil and gas in southwestern Illinois accord with the anticlinal theory. Figure 1[1] shows the location of oil and gas producing areas in southwestern Illinois (except the Waterloo field in Monroe County). Practically without exception they are situated upon, or are closely related to, well-defined anticlinal structures. Most of these anticlinal structures are features both of the shal-

[1]Bell, A. H., The Sorento dome: Illinois State Geol. Survey, Press Bulletin Series, Illinois Petroleum No. 6, Fig. 1, p. 2, Dec. 4, 1926.

lower and of the deeper strata, but are usually more accentuated in the latter.

Choice of a Key Horizon.

The requisites of an ideal key horizon are first, that it shall be an easily recognizable stratum or contact, and, second, that it shall have a stratigraphic position near the prospective oil-bearing stratum. Wide separation of the key horizon from the oil-bearing bed is undesirable because of the chance of unconformity between them.

Structure Mapping in Southwestern Illinois.

In most of the area of figure 1 the presence of an overlying mantle of glacial and fluvial deposits of Pleistocene age prevents the determination of structure by means of surface outcrops. As there is no traceable outcropping key horizon sub-surface structure is determined almost entirely by the use of the data supplied by well borings and mines. Because of the economic importance of Herrin (No. 6) coal in southwestern Illinois more datum points are known for it than for any other bed either above or below, and it is therefore usually chosen as the key horizon for structure maps in this area. It possesses physical characteristics that render its identification easy where it is present in its normal thickness and even in places where it is thin or absent, its stratigraphic position may usually be recognized in carefully kept logs by a correlation of other beds.

Because the vertical section supplied by the diamond drill core shows the strata in their proper order, and because the lithologic character and fossil content of the core may be studied in detail, the geological information obtained from core drilling is, in general, superior to that obtained from churn drilling. The accuracy of maps prepared from sub-surface data varies according to the closeness of spacing of the datum points.

The use of Herrin (No. 6) coal as a reference bed in structure contour maps has the disadvantage commonly attending wide separation of the key horizon and the oil-bearing sand. The most productive oil sands in the general region are of Chester age and are separated from the key horizon by the inter-systemic unconformity at the top of

the Chester. The problem of the relation of Pennsylvanian to pre-Pennsylvanian structure in Illinois is important for its economic as well as its geologic interest.

The use of diamond drill logs not previously employed made possible the revision of the earlier structure map of parts of Bond, Madison, and Montgomery counties.[2] For example, the construction of such new maps as those showing the structures of the Ayers and Sorento domes by 10-foot instead of 50-foot contours has been made possible by the use of data derived from diamond drill records. As a result of this more detailed mapping, structures appear which were not previously delineated (fig. 2[3]).

It might be of interest to know that shortly after the publication in December, 1926, of Illinois Petroleum No. 6, describing the Sorento dome, the acreage on the top of the New Douglas dome was leased and so far, one well, located 40 feet down from the crest of the dome on the southwest flank, has been completed to a depth of 841 feet. Although considerable sand was found both in the Pennsylvanian and in the Chester, it was filled with salt water and there was no showing of oil. A second test is to be drilled higher on the structure.

The continual acquisition of new data by the Survey makes possible from time to time the revision of earlier maps and the delineation of structure in greater detail. A continuation of this type of work constitutes one of the activities of the petroleum section of the Survey. The purpose of this work is to present the most accurate information possible in regard to structures thereby encouraging prospecting for oil in a systematic manner and preventing as far as possible useless expenditure on wild cat drilling in localities that are geologically unfavorable. The generalized character of some of the earlier maps accounts for occasional failures even when the wells were drilled on indicated structures. Moreover, favorable structures even though accurately mapped are not always productive of oil; other favorable conditions besides structure are necessary for the accumulation of oil in commercial quantities. For these reasons many of the oil operators are not fully convinced of

[2]Blatchley, R. S., Oil and gas in Bond, Macoupin and Montgomery Counties, Illinois: Illinois State Geol. Survey Bull. 28, pl. II, 1914.

[3]Bell, A. H., The Sorento dome: Illinois State Geol. Survey Press Bulletin Series, Illinois Petroleum No. 6, Fig. 2, p. 7, Dec. 4, 1926.

the value of geological studies in the development of oil production.

In order that the relationship between geological structure and oil production may be more fully realized, it is clear that the structures should be indicated with the greatest possible accuracy. In demonstrating the usefulness of geological information the Survey has an educational function. Eventually, perhaps, the oil operators of Illinois will employ geologists of their own to a greater extent than at present. The Survey will still have an important function of acting as a clearing house for geological information and of carrying forward the study and interpretation of the ever-increasing mass of geological data from the State as a whole. Thus, by a study of so-called "pure" science, the economic interests of both present and future generations are served.

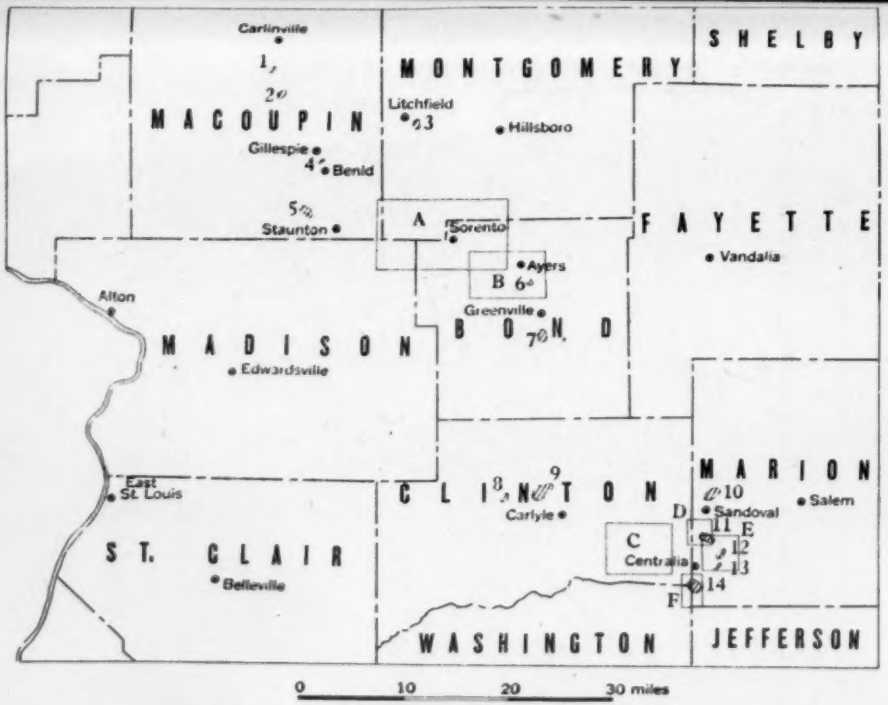

Fig. 1.—Index map showing locations of oil and gas fields in part of southwestern Illinois. Structure of area A is shown in figure 2. (By A. H. Bell, State Geological Survey.)

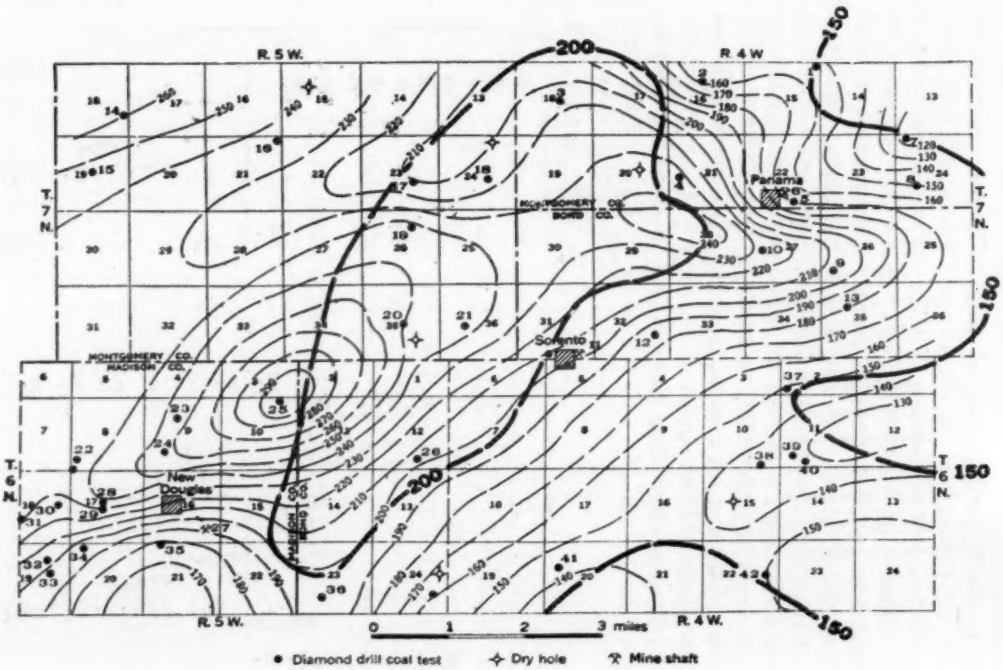

Fig. 2.—Structure of Area A. See Fig. 1.

MUTIPLE-LEVEL CIRQUES.

MARGARET BRADLEY FULLER, NORTHWESTERN UNIVERSITY.

Introduction.

Field studies in the higher ranges of Colorado and Montana show that many cirques at the heads of extensively glaciated valleys are marked by terraces or multiple-levels. Within the cirque proper the walls are shelved and pocketed at all levels from the rock floor to the crested rim of the over steepened walls. At the down-valley end of the cirque "step and riser" topography marks the descent to the main U-shaped valley.

It is also notable in most ranges south of the International Boundary that the existing glaciers are of the small cliff type perched within or along the walls of the cirques made by great Pleistocene glaciers. Locally, as radiating from the summits of Mt. Shasta, Mt. Ranier and other conical peaks of considerable altitude, true valley glaciers exist.

The small, locally active cliff glaciers are responsible for the detailed topography within the giant cirques, and, in the course of their existence, develop a second cycle of glacial erosion and impose marked detail on the larger features of the earlier and more extensive glaciation.

Topography of Multiple-level Cirques.

Lewis and Livingston Ranges, Montana.

Many types of cirques abound in Glacier National Park, Montana. The simplest are nearly vertical walled, flat-floored, tarn-enclosing basins of craterlike simplicity. More commonly the cirques are complex with multiple-levels[1] and subsidiary pockets. Profiles of the cirque walls show distinct, variously elevated levels harboring glacierettes and drifts of nevé from an acre to two or more square miles in extent. Many giant cirques have small living glaciers on the floors at their heads and others perched along the upper walls. Other cirques, although possessed of hanging glacier-

[1]The term "terrace" might well be used to describe the topography of cirque walls as carved by the secondary recent glaciers. Since "terrace" has been used so widely to describe the topography of stream erosion it is not advisable to apply the term to topography described herein. The term "multiple-level" is proposed here to define both topography and mode of origin.

ettes, have no glacier at the foot of the enclosing walls. Fig. 1.

The principles of glaciation and nivation responsible for the recent development of the multiple-level detail within the vast cirques were set forth by Matthes in his studies of the Big Horn Mountains.[2] It will be shown that additional factors in certain regions cooperate to produce the type profile indicated.

Excellent examples of multiple-level cirques appear on the eastern flank of the Lewis Range and the western flank of the Livingston Range. The relationships of the drainage lines and U-shaped valleys to the bed rock have certain noteworthy features:

1. At the east in the Lewis Range and the west in the Livingston Range the great Pleistocene valley glaciers moved down the valleys but up the dip of the strata. This favored unequal gradients along the down-valley portions and permitted the development of "step and riser" profiles. It also favored the scouring and plucking of linked basins along the course of the glaciated valley. At the head of each valley a vast cirque was excavated, where the bergschrund operated down the dip of strata inclined from ten to twenty degrees. The cirque basin evacuated by the glacier was, in many cases, not at the uppermost limits of the preglacial valley.

2. The Grinnell argillites and interbedded quartzite, overlain by the Siyeh limestone of both massive and thin beds, mark the heads of most of the valleys in both ranges. Both formations are easily quarried and plucked by ice and sapped by snow. Differential plucking and scour along alternating weak and resistant beds favored incipient terracing of the cirque walls and the development of secondary bergschrunds. As the ice retreated the main glacier became separated into different lobes at different levels, and each lobe operated as an individual glacier, dug, deepened and scoured its nest and piled up a moraine around it.

3. Snowfields, icefields and glaciers seldom occur now in the bottoms of valleys, but are mostly hung along the upper walls of cliffs, or in pockets close to the summits of divides, due not so much to favorable locations for snow

[2] P. E. Matthes, "Glacial Sculpture of the Bighorn Mountains, Wyoming." U. S. G. S. 21st Ann. Rept. Pt. 2, 1899, pp. 173-190.

drift and accumulation as to places less exposed to sun and wind. The snow line is well above the valley floors, one thousand feet to fifteen hundred feet, and lies close to the summits of divides.

Sperry-Avalanche Region.

At the Sperry-Avalanche region a multiple-level cirque is in the making. Avalanche Basin is a huge "crater" cirque harboring a lake. Fig. A. At the head, the enclosing walls rise over 2500 feet sheer to Sperry Glacier. Sperry Glacier itself rests in a shallow cirque and shelf above Avalanche Basin and covers about a square mile.

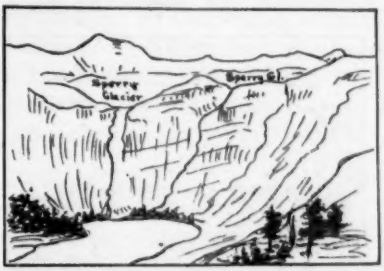

Fig. A. The main cirque of Avalanche Basin with Sperry Glacier hung above and to the rear on a wide shelf. The site occupied by Sperry Glacier appears to have been the upper head of the valley occupied by nevé only and not glaciated at the time the main cirque was excavated.

Recently Sperry Glacier has waned and separated into several lobes, each of which acts as an independent glacier. Each has a well defined bergschrund, is sapping, plucking and nesting into the surrounding walls, each lobe on a rock bench of different level so that the whole area is being cut into multiple-levels, in terrace fashion. Fig. 2.

The crest of Avalanche cirque and the floor of Sperry Glacier is approximately at the top of the Grinnell quartzite. The base upon which many other recent glaciers of cliff type rest is somewhat predetermined by the contact between weaker and more resistant formations. The well defined levels of secondary cirques within and along the walls of the primary amphitheaters lie, in many places, at the top of the Grinnell formation and at the base of the Siyeh.

Matthes[1] noted that the cirques in the Bighorn Mountains are not everywhere at the heads of the valleys but that "the upper ends of the preglacial valleys remain unglaciated above the present sites of the amphitheaters." The upper end of the valley is, in most cases, an open, much nivated bench above the site of the glacier which cut the amphitheater. Within Glacier Park, in both Lewis and Livingston Ranges, such benches are the most favorable sites of existing glaciers. Thus Sperry Glacier lies nearly 2500 feet above the cirque of Avalanche Basin, Harrison Glacier nearly 2000 feet above Harrison valley and cirque and Grinnell Glacier over 1500 feet above Grinnell cirque and lake.

As a rule recent glaciers lie upon flats and in shallow cirques newly created and above the main amphitheater

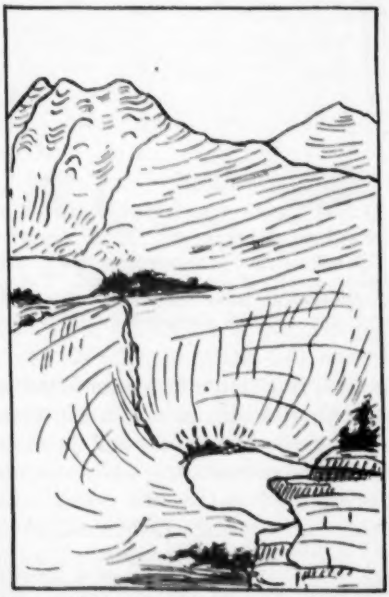

Fig. B. Cirque of Little St. Mary's Lake and the upper cirque of Lake Ellen Wilson above it. The third level is to the left above and out of the view.

made during Pleistocene cycles. It is believed that the present glaciers are not in many cases the survivors of the formerly extensive and thick valley glaciers which shaped the

[1] F. E. Matthes, *op cit.* pp. 178-179.

great cirques and U-shaped valleys, but are recently accumulated masses, in many places occupying sites unaffected by the early cycle and above the cirques made during the earlier cycle of glaciation. The present snow line ranges from an altitude of 6000 feet near the International Boundary to 6500 feet thirty miles south and is well above the rim of the giant cirques.

Along Little St. Mary's valley there are two great cirques. One encloses Lake Ellen Wilson and heads at Gunsight Pass. The other is farther down the valley, a sheer drop of 1500 feet, and is occupied in part by Little St. Mary's Lake. Fig. B. No remnant of either the earlier glacier responsible for Little St. Mary's cirque or the latter glacier which carved the amphitheater of Lake Ellen Wilson remains now. The action of successive cliff glaciers at successively higher levels towards the heads of valleys along the west slope of the Livingston Range has cut marked areas into multiple-level cirques, all linked in series.

Swiftcurrent Region.

Swiftcurrent valley exhibits a later step in the development of a multiple-level cirque. Along the Garden Wall Swiftcurrent Glacier and Grinnell Glacier with Gem Glacier above are active in cutting new levels within the giant cirques. Grinnell Glacier has more than half obliterated the wall of its ancestor. The results of nivation as carried on by snow and nevé banks are evident in small "cirques" all along the Garden Wall.

Two Medicine Region.

The Two Medicine region is nearly twenty miles southeast of the Swiftcurrent area and at a slightly lower altitude. Active glaciers are lacking and snow and nevé banks alone are responsible for the recent sculpturing detail in the great Pleistocene glacier cirques. Along the bases of cirque walls on shelves up to the rims the nevé banks have sunk pockets into the sheer walls, and are continually spilling talus and the "talus moraine" which normally encircles the snow bank rim, over the edge of the shelf to talus cones below. Fig. 3.

The cirques at the heads of valleys draining the Two Medicine region exhibit the last stage in the secondary glaciation cycle. The small active glaciers and glacierettes have melted and only ice and snow banks continue on a small scale to pocket the walls by nivation and impose upon the major earlier amphitheaters, developed by the Pleistocene valley glaciers, a wealth of small detail and local relief.

In the final stage the snow and ice banks have disappeared entirely and the minor cirques, multiple-level terraces and pockets have filled with talus and lost the amphitheater outline through exfoliation and frost action. Such conditions are evident south of the Park.

Front Range in Northern Colorado.

Multiple-level cirques in the Ranges of Colorado are less well developed than those in Glacier Park. It appears that the massive granite and gneiss of the region is less favorable for the ready cutting of shelves and pockets by nivation and plucking. Hence the erosion by recent glaciers is poorly defined and not readily recognized.

Along both east and west slopes of the Continental Divide the Pleistocene valley glaciers carved marked amphitheater cirques in granite and gneiss. Present glaciers are of the cliff type and situated high on the walls of the cirques. Such glaciers are shaping the major cirques into multiple-levels. Nivation by snow and ice is a minor feature. The multiple-levels of Glacier Gorge to the west of Longs Peak are marked by small lakes and but little moraine. Other great cirques exhibit similar detail.

Steps in the Development of Multiple-level Cirques.

1. A' valley glacier at its maximum stage, by sapping, developed a steep-walled cliff enclosing the head of the glacier. The amphitheater created was, in some cases, not at the head of the pre-glacial valley. Avalanches brought down loose rock from above and the scaled-off talus glissaded over the snow and ice to join the moraines.

2. The valley glacier receded so as to abandon the major part of its valley. Remnants of ice were left nested in the bottom of the cirque or perched high on cirque walls. Such small glacierettes, by plucking and nivation, dug in and deepened the rock floors so as to pocket the walls. The products of such erosion, together with talus from cliffs

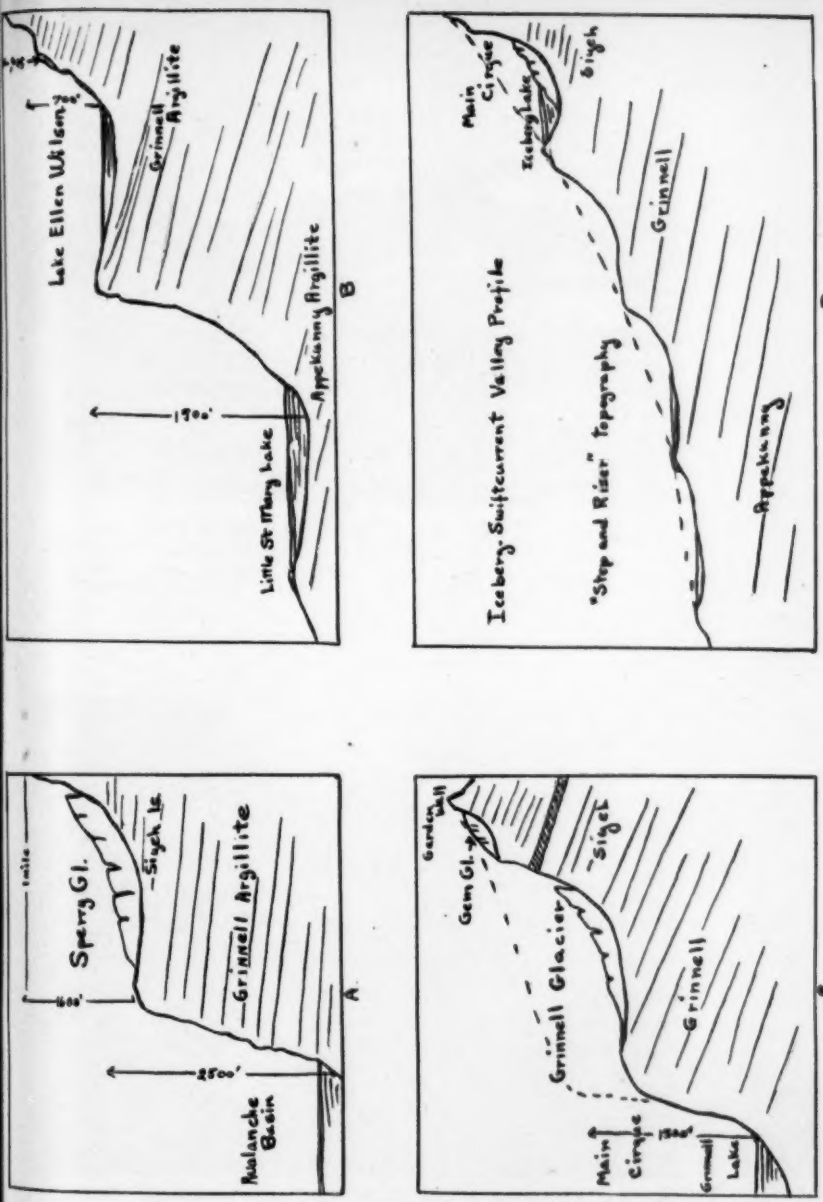

FIG. 1. PROFILES OF MULTIPLE-LEVEL CIRQUES.

(a) Shows the main cirque of Avalanche Basin and cirque wall up to Sperry Glacier which is perched in a secondary and somewhat shallower cirque above the main cirque.

(b) In the Little St. Mary's valley the glaciers of both upper and lower cirques have vanished, leaving three levels well established.

(c) Profiles of Grinnele cirque, Grinnele and Gem Glaciers, show three multiple-levels in the making.

(d) In the Iceberg Lake-Swiftcurrent valley only one level of cirque is evident. Note that the down-valley end is marked by "step and riser" topography.

Fig. 2. View of Sperry Glacier in 1926 (August) showing its separation into different lobes at different levels, each lobe operating to nest itself into a separate cirque. Vertical distance in the view is about 1500 feet and the horizontal distance about three-fourths of a mile.

Fig. 3. Detail of main cirque wall showing small subsidiary glaciers (a) hanging glacier carving a secondary cirque and spilling moraine and talus to a cone below (c); (b) small glacier at foot of a cirque wall with typical horseshoe moraine.

above, accumulated in a horseshoe moraine or was spilled over the narrow shelf to the floor below. In some cases recent glaciers are not survivors, but are newly gathered and occupy sites hitherto unglaciated, such as the shallow benches marking the heads of preglacial valleys, situated above the present highly elevated snow line. The small glaciers which survived from the earlier and more extensive epoch, as well as those which are obviously of recent gathering, are maintained because of strategic position for snow accumulation and along shaded cliffs.

3. The small cliff glaciers continue to excavate basins commensurate with their size and carve the walls of the giant cirques into multiple-levels as long as they survive. It is believed that the majority of such glaciers are relatively short lived.

4. With the exception of cirques and shelves developed by glaciers the size of Sperry and Grinnell, the small cirques abandoned by the ice and the pockets developed by nivation, once empty, soon fill with talus and harbor less and less of drift each year. In this way the record of such small moraine-rimmed pockets or moraineless shelves is soon obliterated.

Summary.

It appears that small cliff glaciers operating within and along the walls of the earlier developed amphitheaters, as well as those perched above the rims of giant cirques, mark the recent cycle of glaciation. Such cliff glaciers impose distinct but small scale detail upon the older topography. They develop multiple-level cirques within and about the giant amphitheaters created by the Pleistocene valley glaciers.

THE PHOSPHATE ROCK INDUSTRY OF MOROCCO.

FRED S. MOHME, UNIVERSITY OF ILLINOIS.

Phosphatic material, such as animal refuse, bones, fish, and guano have been used for fertilizer for such a long time that it is nearly impossible to state when its application as such was first discovered. However, it was not until the discovery of the mineral phosphates that the artificial fertilizer industry rose to such magnitude that today abundant supplies of this mineral have become indispensable. Fortunately the beneficence of nature insures us vast deposits of mineral phosphates.

One of the richest phosphate fields, probably only surpassed by that of the United States, is the Moroccan. It is found in three fairly large areas, all on the Tertiary and Quaternary tableland nearly 100 miles broad, bordering the Atlantic Ocean.[1] Of these regions the northernmost one, about 80 miles southeast of Casablanca and including Oued-Zem, El Boroudj, Guisser, and Kasba Tadla on the north,

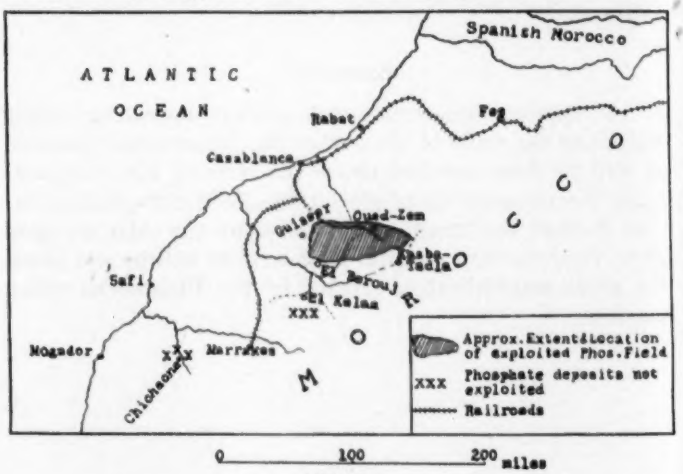

FIG. 1.

south, east, and west sides respectively, is the only one that has been explored in any detail, and at present the only one

[1]Stone, R. W. *Phosphate Rock*, U.S.G.S. Min. Res. of the U. S. 1919, Pt. II, p. 222.

mined.[2] (Fig. 1). This field covers an area some 75 kilometers in length and from 5-35 kilometers in breadth. The phosphate found here is in the form of fine grayish sand, friable, and with a high percentage of phosphate of lime (73-78%). As regards its quantity the estimates vary from "many millions" to "hundreds of millions" of tons. G. R. Mansfield of the United States Geological Survey places the reserves for this northern area at 1,000,000,000 metric tons.[3]

The phosphate beds, separated by calcareous beds, clay, and a low percentage of phosphatic marls, consist of horizontal layers varying in thickness from a maximum of 65 feet in the north at Oued-Zem to 98 feet at the south in El Boroudj.[4] From a topographical point of view they present the appearance of a plateau rising gradually from the north to the south, and since this plateau is criss-crossed by a number of intermittent streams the erosion caused thereby has made prospecting for the phosphate a comparatively simple matter. It has likewise made both surface mining and horizontal tunneling possible. The deposits, however, are not continuous throughout the district above described, and their value fluctuates with the variation in the grade. In many places the grade is too poor to be commercially recovered, and unfortunately this is often true of the thickest beds.

At El Boroudj cliff, which is the southern boundary of this exploited field, erosion has caused the phosphate to disappear, but it reappears further south in the region of El Kelaa. About 60 miles to the southwest of this field another layer of phosphate makes its appearance, which is known as the Chichaona-Imintannt field. Both of these beds, said to be as much as 200-275 feet thick in places, form parts of the same sedimentary series that is present in the Algerian and Tunisian deposits. However, no attempt at exploitation in these regions has as yet taken place.

Production.

The development of the phosphate rock deposits of Morocco has proceeded with almost unprecedented vigor.

[2]Mansfield, G. R. *Phosphate Reserves Ample for 2000 Years*, Engineering and Mining Journal, vol. 122, No. 21, p. 812.

[3]Mansfield, G. R. *Phosphate Reserves Ample for 2000 Years*, Engineering and Mining Journal, vol. 122, No. 21, p. 812.

[4]Loyd, S. L. *Moroccan Phosphate Deposits*, Engineering and Mining Journal, vol. 113, April 8, 1922, p. 565.

From an output of 6,981 tons in 1921, the production has increased to 720,680 tons in 1925[5] (Fig. 2). When the Protectorate (the French) realized that the phosphate deposits were of such enormous extent and value they made the entire exploitation a matter of State monopoly, which greatly facilitated the construction of railroads, port equipment, and mines. To this can be attributed largely the phenomenal increase in production. However, the scarcity of labor limits the output. It has been said that in order to bring the production up to 1,000,000 tons per annum 20,000 miners will have to be employed, which is more than the total population of the region under development.[6] Furthermore, the labor supply, being largely recruited from the country-side, is curtailed during the ploughing and harvesting seasons. As yet wages are not high enough to induce foreign labor to come to Morocco. The extent of the deposits being practically unlimited, it would seem that production is entirely dependent on the demand and the availability of labor.

Exportation.

There are no statistics concerning the domestic consumption of phosphate fertilizer, but it is understood that prior to 1925 the amount was negligible. Consequently, practically the entire output is exported. It appears, however, that the producers are either not attempting or have been unable to place their products extensively in other markets than those of Europe. The only exceptions are small amounts that are sent to the Union of South Africa and to Australia (Fig. 3). The European market is canvassed thoroughly, a policy which apparently seeks to establish a well-rounded demand that will give greater stability to the industry. The expansion of the European buying market will admit the ready disposal of increased output. Morocco exports only the high grade phosphate, which since the war has been especially demanded by the trade. It is the high-grade Moroccan rock that competes so strenuously with the high-grade Florida phosphate, for in 1925 Europe consumed 721,227 tons of Moroccan phosphate as compared with 614,571 tons of high-grade Florida phosphate (Fig. 2).

[5] Waggaman, W. H. *Phosphate Rock*, The Mineral Industry, vol. 34, p. 552.
[6] *Ibid.*, p. 553.

Although no figures as to the cost of extraction and carriage of the phosphate to the port of Casablanca has been announced, the price of phosphate at English and French ports amounted in 1924 to only $5.25 per ton.[7] This amount appears exceedingly low, when it is considered that the mineral must be extracted, sorted, crushed, loaded on cars and carried 80 miles to Casablanca, loaded on ships and transported to the various foreign markets. No doubt, in order to permit a greater profit, the producers are endeavoring to reduce transportation and handling costs by manufacturing super-phosphate (which is the concentrated form of phosphate fertilizer) in Morocco. This high-grade product can more readily than the raw product support the freight rates. The preparation of super-phosphates has already been started in a small way at Casablanca.

Morocco's Future in Phosphate Production.

Although active propaganda to increase the sales of Moroccan phosphate is being carried on by the French, several economical and geographical conditions greatly facilitate the exploitation of this field. These are:

1. Moroccan ports are exceedingly well-placed geographically to secure favorable freight rates to the European markets.
2. Phosphate deposits can be mined more cheaply than any other known deposits because of (a) horizontal beds, (b) high percentage of phosphate of lime, (c) proximity to the coast, (d) soft texture of the rock which is highly desired in the manufacture of super-phosphates.
3. Morocco can furnish, if necessary, all the standard grades of phosphate from high to low.
4. Facilities for railroad construction from the coast to the mines are excellent.
5. Low wages and assistance from the French Government stimulate sales.

The Moroccan enterprise has been in existence only since the war, but already it is third in world production. As time goes on it is highly probable that Europe will secure the bulk of its supply from the North African phosphate fields (the high grades from Morocco and the lower grades

[7] Mansfield, G. R. *Phosphate Rock in 1924*, U.S.G.S. Min. Res. of the U. S. 1924, Pt. II, p. 102.

from Algeria and Tunisia). The physical characteristics of the phosphate, its accessibility from the mining standpoint, and its transportation facilities are the chief factors governing price, which in turn determines sales. Since Morocco is especially favored in these respects, she should be able to maintain a commanding hold upon the European market.

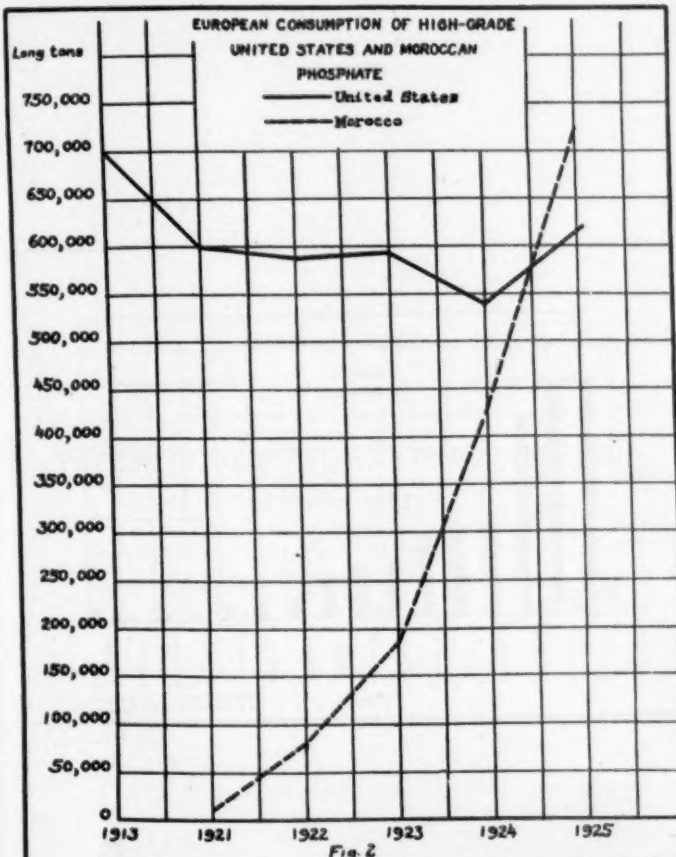

Fig. 2

The exports of Moroccan Phosphate rock to Europe approximately equals the total production since domestic sales and the deliveries to other countries than Europe are almost negligible.

Main Data for U.S. from Min. Res. of U.S. Pt. II, 1925, p. 181, for Morocco from letter to writer from A.D. Cameron, U.S. Consul, Paris, France, Mar. 1927.

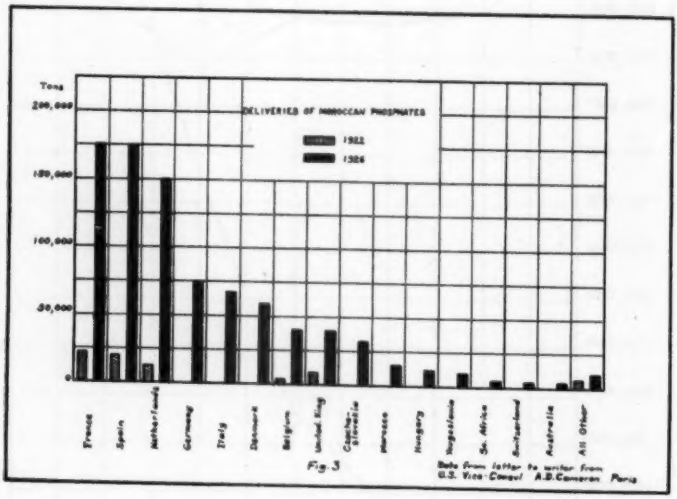

Fig. 3

Data from letter to writer from U.S. Vice-Consul A.B. Cameron, Paris

PAPERS IN MEDICINE AND PUBLIC HEALTH

SECTION, JOLIET.

RABIES IN ILLINOIS.

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When the old Greeks looked up into the heavens, they imagined that they saw all sorts of curious figures and animals outlined by the stars. Thus the stars were grouped into constellations and named after the animals and gods they represented. Modern astronomers continue to use those names for star groups. If on a clear winter night you face south and look up you will see in front of you "The Great Dog" dominated by a particularly bright star "Sirius," or the "Dog Star". In July and August this star rises with the sun and to it the ancients attributed the great heat of the season as well as the cause of dogs going "mad".

"Mad dogs" have been known as far back as history goes. The Greek philosphers Aristotle and Plutarch wrote about the disease under the name "hydrophobia" (fear of water). From Rome we hear of it through the writings of Vergil and Ovid who called it "rabies" (from the Latin rabere, to rave).

The notion of the ancients, and which still prevails, that rabies is a hot weather disease, is erroneous. It is true that the disease may be prevalent during the summer, because dogs are out of doors to a greater extent and hence come into contact with each other more. This seems to be the case in Illinois as evidenced by the number of heads of rabid animals received both at the laboratory of the State Department of Public Health in Springfield and of the Chicago Health Department. In other communities, however, notably New Jersey, Kansas and Washington, D. C. March is the month of greatest prevalence, with August the lowest month of the year.

History does not reveal when rabies first appeared in Illinois, but we can be quite certain that it was not long after the white man settled here and established communication with the outside world.

Rabies is on the distinct increase in the State at the present time. For many years the disease was very prev-

alent in Chicago but it has fallen off markedly due to compulsory muzzling and leashing of dogs and catching of stray animals. More than 10,000 strays yearly are picked up in that city. On the other hand very few animal heads were formerly received for examination in laboratories downstate, but since 1923 the number has been increasing rapidly at the laboratories of the State Department of Public Health at Springfield and Carbondale, and the Department of Animal Pathology at Urbana.

The spread of rabies over the state has been in the form of a wave northward. In 1924 the State Laboratory at Springfield found the unprecedented number of 39 positive examinations, all from the southern counties; the next year number jumped to 60, with the disease advanced farther north, while in 1926 there were 140, reaching up as far as Will County.

Laboratory examinations for rabies are made by various institutions throughout the state—State Department of Public Health, University of Illinois, Chicago Health Department, Chicago Pasteur Institute and others. Not only are dogs' heads examined but other animals, for all warm blooded animals are susceptible to the disease,—horses, cows, cats, squirrels, even skunks have been received by us. The examination is the same in each instance. The skin over the skull is laid back, the skull cap removed, the brain exposed, a small section pressed out between glass and stained after a certain manner. If the animal was rabid usually typical Negri bodies are easily seen in the brain cells. It is not known for certain whether these are protozoa that cause the disease, or are degeneration products of the brain tissue. They are always found in the brain of well advanced cases of the disease however.

Human deaths from rabies have been increasing both in Illinois as well as over the country as a whole. In the United States for the last three years there was an average of 84 human deaths yearly. In this State there were 4 last year.

Anti-rabic vaccine, if taken promptly, is a sure preventative of the disease. If too much time elapses after the bite, sometimes the patient dies in spite of the vaccine. None of the four persons who died in Illinois last year had

received vaccine. Even when an animal is rabid, only one in six of the persons it bites will contract the disease even when no vaccine is taken. The other five escape through various causes—probably because the dog's teeth are wiped free of saliva by the clothing of the victim.

By the use of anti-rabic vaccine the Pasteur Institute in Paris was able to save 165 to every one that died, this one dying because of delayed treatment or other causes beyond their control.

The Chicago Pasteur Institute increased this figure to more than 750 saved to one death using the original Pasteur method. Since 1910, among the thousands of persons treated this institution with improved methods has not lost a single patient.

This is the experience of many institutions. In Illinois the State Department of Public Health distributes anti-rabic vaccine free of charge to those unable to pay for it.

The credit for the discovery of anti-rabic vaccine goes to Louis Pasteur. In past days some of the most horrible outrages imaginable were perpetrated against persons who had been bitten by rabid dogs,—strangling, suffocating or bleeding to death of the poor victims. On July 6, 1885, after numerous experiments on dogs, Pasteur administered the material to the first human being. This story of Pasteur and Joseph Meister is one of the most gripping and touching ever written. But the little boy, horribly torn and mangled by the mad dog as he was, lived, as thousands have done since.

The control of rabies in a community depends principally on the control of dogs. A suspected animal should not be killed but *chained* securely in a safe place with regular care and attention. If after a week or ten days it has shown no symptoms, it can be released and any persons bitten need take no anti-rabic treatment. If, on the other hand, it develops symptoms of rabies, the animal may be killed and the head sent to the laboratory for examination. If sent in before any symptoms have occurred, the laboratory examination may be unsatisfactory, and leave the patient in more doubt than before.

Any community may rid itself of rabies by requiring the leashing, muzzling or impounding of all dogs, or as a

substitute the vaccination. Of course, stray and ownerless dogs should be destroyed.

Positive Laboratory Examinations for Rabies

	Chicago	Springfield	Urbana	Carbondale
1911	119	3	...	...
1912	116	0		
1913	83	0		
1914	122	0		
1915	119	0		
1916	40	0		
1917	11	0	—*	
1918	26	0	—	
1919	19	2	—	
1920	30	0	—	
1921	44	2	1	
1922	56	1	2	
1923	57	2	5	
1924	59	39	25	
1925	21	60	23	4**
1926	17	140	69	12

*Laboratory of Animal Pathology established 1917.
**Carbondale Laboratory established in 1925.

THE IMPORTANCE OF REST IN THE TREATMENT OF PULMONARY TUBERCULOSIS.

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In the modern treatment of pulmonary tuberculosis three important factors are recognized; namely, food, fresh air and rest and we are realizing more and more that the greatest of these is REST. In fact as Doctor Stewart of Manitoba has said, "REST IS THE CURE."

When we realize that the average healthy individual spends about ⅓ of his life in sleep and several hours more in freedom from work to repair the ordinary wear and tear incident to life's activities, how much more rest should be required when tissues are injured by disease and when at this time extra demands are thrown upon them? During sleep, which more nearly approaches complete rest, all cellular activity is lessened, mental exertion ceases, muscular activity is lessened, metabolic changes decrease, temperature lowers, circulation becomes slower, blood pressure is reduced and respiration becomes slower and much shallower. When the lungs are the seat of disease, it is necessary that the body cells have the minimum demands upon them.

The ordinary case of tuberculosis requires rest and care for a long time—years rather than weeks or months—and even after all activity has ceased in order that the reparative process may go on.

The longer I work with tuberculous patients the more firmly convinced I am of the necessity of a more absolute rest, carried out for longer periods of time even after there are no signs of activity.

ULTRAVIOLET RADIATION AND LIVING PROCESSES.

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Various physical and chemical agents have been shown to be capable of influencing life processes in either of two directions, stimulating or inhibiting them, depending on the dosage used, and the degree of susceptibility of the tissue concerned. Ultraviolet radiation and visible light (plus the action of a sensitizing dye) are no exception. Radiation studies covering a five-year period, beginning at the Nela Research Laboratory in Cleveland, and continuing at the University of Chicago and at Woods Hole, Mass., have included the following types of experimental study: activation of eggs of star-fish and sea urchins by means of ultraviolet radiation[1,2] and visible radiation plus the action of a sensitizing dye;[3] stimulation of frog muscle and nerve by means of radiation in the same two spectral regions;[4] differential disintegration in Protozoa,[5] the lower Metazoa,[5] and early embryos[6];[7] modification of development in Arbacia[6],[8] Fundulus,[9] and the chick;[7] inhibition of the fertilizing capacity of Arbacia sperm;[10] inhibition of the fertilization reaction in Arbacia;[11] and the modification of the division rate in Paramecium.[12]

In the three first-named studies, there has obviously been stimulation of a passive system to an active one. In the case of egg-activation, ripe unfertilized echinoderm eggs were stimulated to develop without the addition of sperm, simply by the action of radiation upon the surface of the egg. Radiation, then, may be added to the long list of parthenogenetic agents, though its efficiency is relatively low when measured in terms of the numbers of free-swimming larvae produced. Activation is often incomplete, resulting only in membrane formation.

Radiation in either of the two above-mentioned spectral regions, when allowed to impinge directly upon the surface of an excised gastrocnemius muscle of a curarized frog will augment the twitching induced by the salt solutions in which the muscle is suspended, and will finally produce contractions. Under properly regulated conditions,

these contractions may, within a short period of especial reactivity of the muscle, coincide fairly well with the time of flashing on of the light. In another series of experiments, radiation, impinging directly on the sciatic nerve of a nerve-muscle preparation stimulated the nerve. The impulse was carried by the nerve to the muscle and the latter contracted.

Obviously, the ripe unfertilized egg and the sensitized muscle are biological systems in dynamic equilibrium with their environment, yet are easily activable. Stimulating doses of radiation as used in the above experiments, rarely exceeded a period of duration of a few seconds in the ultra-violet experiments, and a few minutes when visible radiation was used in the presence of a sensitizing dye. When longer exposures are made, inhibition of normal life processes occurs, often resulting in death and disintegration.

Such a series of experiments were made with Stentor, Hydra, Planaria, Arbacia larvae, and chick embryos. The results may be summed up as follows: Those regions of the body which at the time of exposure, have the highest rates of physiological activity, are the first to die and disintegrate. The rate of disintegration is a function of the relative rates of physiological activity of the various body regions, and consequently there appear in the radiated organism, gradients of death and disintegration coincident, in general, with the metabolic gradients present. In other words, in lower animals and in early embryos, the disintegration gradient is a simple anteroposterior one, while in higher animals and later developmental stages, such simple gradients are obscured by the appearance of local regions of high physiological activity.

With sub-lethal doses of radiation, (i. e., doses which are not immediately lethal) it is possible to modify embryonic development. Such studies have been made with eggs of Arbacia (where exposures were made before and after fertilization, and in another series, where eggs were fertilized by radiated sperm); with eggs of Fundulus (radiated at various intervals after fertilization); and with hen's eggs, (where exposures were made for varying periods before incubation, and at different intervals after incubation.)

While the embryos appear characteristically modified according to species, the results agree in their main features, namely, the regions of the embryo, which at the time

of exposure had the highest rates of physiological activity, are most readily modified in their development, and the liability to modification of specific region depends on the relative rate of this region as compared with that of the rest of the body. Embryonic development may be either accelerated or inhibited, depending upon the dosage of radiation employed. In either case, the regions of highest activity are the first to be modified. With accelerating doses, the resulting embryos exhibit the characteristics of differentially accelerated forms in which the most active regions have attained a relatively more rapid rate of growth than normally. With slight doses, differential recovery appears, while with longer doses, differentially inhibited forms result. The proportion of specific types of abnormalities produced varies with the period of development at which exposures are made, e. g., in Fundulus and in the chick, modification of development of the circulatory system, and of the sense organs and brain parts appears in the largest proportion when exposures are made early in development. Inhibitions of the developing tail region appears when exposures are made much later in development. The most favorable period for the production of modifications in the development of a particular organ appears to be just previous to the time when the organ makes its morphological appearance, that is to say, when the preprimordial stage is reached, such a region has a relatively high rate of physiological activity, and in consequence, is most intimately dependent on its environment for its subsistence, and most readily registers the results of any environmental change which produces a deleterious action on life processes.

Two other methods of studying the inhibitory action of ultraviolet radiation were made as follows: Arbacia sperm were radiated, and were found to lose their capacity for fertilizing normal eggs, as well as their agglutinability by normal egg-water; also, Arbacia egg-water loses its power of agglutinating normal sperm. The rate of loss of both these activities is a function of the dosage of radiation employed.

A series of experiments, now in progress, demonstrates the effect of ultraviolet radiation on the division rate of Paramecium caudatum. Here again, small doses, i. e., less than 5 seconds at a distance of 12 inches from the arc,

stimulate the rate of division, while longer doses depress the rate. Inhibiting doses applied early in the division cycle may inhibit division to such an extent that the two daughter cells are unable to separate. There results therefore, a considerable proportion of "permanent" pairs. A second exposure, (and occasionally a third, where both members of the pair do not divide simultaneously,) will further inhibit the division of each of the components of a "permanent" pair, and may, in a small percentage of cases, produce "permanent" 3- and 4-celled Paramecia. Further study is being made of the optimum conditions for the production of 4-celled forms and of their behavior and viability.

In conclusion it may be stated that, (1) living organisms are differentially susceptible to radiation, and (2) that dosage is an important factor in determining whether such effects shall be stimulative or inhibitory in nature.

LITERATURE CITED.

[1]Lillie. R. S. and Baskerville, M. 1922. Am. Jour. Physiol. 61, pp. 57-71.
[2]Lillie, R. S. and Baskerville, M. 1922. Am. Jour. Physiol. 61, pp. 272-288.
[3]Lillie, R. S. and Hinrichs, M. A. 1923. Anat. Rec. 26, p. 370.
[4]Lillie, R. S. Unpublished.
[5]Hinrichs, M. A. 1926. Biol. Bull. 50, pp. 1-16.
[6]Hinrichs, M. A. 1924. Jour. Exp. Zool. 41, pp. 21-31.
[7]Hinrichs, M. A. 1927. Jour. Exp. Zool. 47, pp. 1-34.
[8]Hinrichs, M. A. 1926. Biol. Bull. 50, pp. 455-472.
[9]Hinrichs, M. A. 1925. Jour. Morph. & Physiol. 41, pp. 239-265.
[10]Hinrichs, M. A. 1927. Biol. Bull. Zool. 50, pp. 473-265.
[11]Hinrichs, M. A. 1927. Biol. Bull. 53, pp. 416-437.
[12]Hinrichs, M. A. 1927. Unpublished.

X-RAY AS A REMEDY IN BENIGN DISEASES OF WOMEN: A REVIEW OF 455 CASES—COVERING 10½ YEARS.

MARY ELIZABETH HANKS, M. D., CHICAGO.

To report in a few minutes 455 cases covering ten and a half years' work is impossible. However, a statement of the practical aspect of x-ray may be undertaken with the hope that this brief survey may result in a better appreciation of x-ray as a benignly efficient agent in the nonsurgical treatment of women's diseases. I am convinced that certain pathologies in the generative organs of a woman belong to the x-ray therapist and that, exclusive of cancer, these diseases are better treated with the low voltage and fractional doses. This technique being more deliberate, gives, as Nature does, abundant time for readjustment. It is also the safest, most conservative method, and may be so applied that it is free from undesirable results. There is no injury to tissues adjacent to the pathology under treatment and no "x-ray sickness." The patient can immediately and continuously go about her business. There are no detrimental blood changes, no secondary sex manifestations such as obesity, loss of normal sex impulse, etc., because the endocrine balance is not disturbed. When the menopause does follow it is not so precipitate and stormy, as after radical operation.

Another important reason for preferring low voltage, and small doses gradually applied is that in younger women the x-ray effect may be limited in most cases so that the pathology is reduced without profoundly influencing ovarian functions and the menses. Until recently I have not accepted the younger women for x-ray so I have only nine cases in which the menses were resumed in from four months to three years. One conceived and bore a normal child at full term. Of the possibility of pregnancy I cannot judge, however, because five were unmarried. I have recently been strongly upheld in this effort with younger women by reports from Newcomet (1) of Presbyterian Hospital of Philadelphia and Knox of St. Luke's, New York (2),

the latter stating that even in women of twenty-five years of age the menstrual function may be impaired only temporarily. I have had 40 cases under 40 years of age. Twenty were less than 35 and the youngest 26.

What is the effect of small doses of x-ray on the tissues? A brief answer to this question follows:

1. X-ray inhibits ovarian stimulation. The ripened follicles and the ripening follicles are usually destroyed but the primordial follicles, if x-ray is discreetly applied, will later develop (3).

2. The internal secretion is apparently not influenced by the conservative application of x-ray (4).

3. The blood vessels are reduced in size by the effect on the endothelial lining of the capillaries, thus limiting the too abundant blood supply (5).

4. The glandular tissues both in the body of the uterus and in the cervix are directly influenced. They become less in size and function, thus adding to the increasingly normal picture.

5. The fibroid tumor cells gradually disintegrate in a regular order, and in favorable cases are finally carried away by the leucocytes.[6]

In the average case all these changes are necessary to recovery, and if the x-ray operator has the judgment to stop when his work is done, nature at her best is imitated and no harm results.

The pathology most frequently presented for x-ray treatment is fibroid tumor of the uterus, of which we have treated 286 cases. For practical purposes these fall into three groups. First, those unfavorable to x-ray that should not be accepted because of serious complications or because of symptoms suggesting necrosis, cystic degeneration or cancer; second, those less favorable, who for sufficient reasons should be accepted. This group includes women who are not good surgical risks at the time of treatment but who may later become so because of improved general health. In some cases, however, surgery will probably never be possible and the x-ray therapist can here offer a definite relief. This group may include those who cannot turn aside from compelling responsibilities at home or in business, and also those who refuse to submit to surgery.

From this group, however, we have had some surprising successes, and from this group also may come an occasional disappointment, as will be seen later. The third group and the best, are those of the intramural type of tumor that are hemorrhagic. These are most favorable to x-ray and yield 100 per cent in satisfaction. The great majority of these tumors disappear, and fortunately this favorable type occurs in 75 per cent of all cases. They are ideal cases when the fibroid is situated below the umbilicus, is not seriously complicated and occurs in a woman of 38 years or more.

Apropos of the above question of selection, I find that as my experience grows and my judgment in diagnosis, prognosis, technique and management becomes more reliable, I am accepting cases that I would have once refused. This is possible because I find that a much larger percentage respond to treatment and return to health than I at first thought possible.

Here, in fairness to the subject, I must include a paragraph of my failures that came to operation. As I look back I see that they have come mainly through errors in diagnosis.

The first was a myxomyoma. That is rare, almost never diagnosed until after operation. Next came a fibrocystic tumor of the ovary in median position. Then a cancer of the fundus uteri was accepted after a negative hospital report. The next was a fibroid tumor closely associated with a dermoid tumor. The fibroid disappeared, the dermoid remained. The next case gave me great anxiety and regret. She was a very poor surgical risk and also was unsuited to x-ray. The tumor was large, multiple and hemorrhagic to an unusual degree. The complication was one of the worst cases of exophthalmic goitre I ever saw. X-ray shrank the tumor, reduced the hemorrhage and so improved general health that the goitre gradually subsided. But the hemorrhage would recur. Radium was finally applied the third time before hemorrhage disappeared. Five years of good health followed. Then a papillomatous cyst of the ovary required operation. The small fibroid remaining seemed so innocuous that it was not removed, because of the risk of too long an operation. Again she became

well and resumed her work. But a year later, seven years after treatment began, she died of a malignant growth the nature of which was not determined. This case is reported more in detail because it is my only case of cancer which developed after a thorough irradiation.

Submucous fibroids are a complication that may defeat the ideal result and they often escape early diagnosis. These are said to occur in about 10 per cent of the cases. Eight per cent usually recover with the fibroid. Two per cent either prolong the hemorrhage, which finally ceases, or they may require curettage to complete the cure, or as in one of my cases, by developing a suspicion of malignancy may lead to operation. Not one of my group, however, has been malignant. Béclère reports seven of these failures out of 700 cases (7). This corresponds to my own experience. One case in which the large tumor had disappeared was curetted and cured—one was operated upon. This was a very complicated case, at first a poor surgical risk which became under x-ray a good risk. The tumor and adhesions were much reduced but bleeding occasionally recurred. The health, however, was greatly improved and the patient was then operated upon successfully. Another case was so improved under x-ray that a dangerous and radical operation was changed to a simple non-mutillating one.

Beside fibroid tumors x-ray remedies the following:

The menopause often plays the part of a bad citizen or an outlaw. We deal with these cases when hemorrhage is the principal offense, or when, with a multiplicity of smaller offenses, the patient becomes a nervous wreck, her general health suffers and her whole family becomes discordant. The hemorrhage may become a serious matter even though gross pathology may not be demonstrable. There is, however, as Samuel Geist has well established, a histologic picture in the endometrium that is pretty constant. He finds hypertrophy of the mucosa, edema of the stroma and enlarged glands which may be cystic (8). Though these changes are comparatively small and not palpable, I contend they are pathologic and should be dealt with. My 20 cases have all responded to x-ray after a few weeks and good order again reigns in the small community.

The ovaries, when they present the small follicular cysts, should not be patched or removed. These cysts may grow to the size of a lemon, but under x-ray they recover promptly with the fibroid tumor. I have a list of 63 cases that are well.

The large ovarian tumors are always surgical. They are not caused, nor prevented, nor cured by x-ray.

The cervix uteri, where cancer prefers to attack, should be cured long before that tragedy. In cases of cystic degeneration of cervical glands, with erosions that are sometimes extensive and threatening, and the resulting leucorrhea, the x-ray is a dependable remedy, and the response to treatment is prompt and satisfactory. To date no case of cervicitis has developed cancer, though we have had several that required follow-up treatment. We have treated 68 cases.

Dysmenorrhea, the type that resists all measures, that incapacitates the sufferer, that makes of her a haunted invalid throughout the month, should be ended with x-ray. These cases, 18 in number, have come so promptly into good health that they have given great satisfaction.

Adhesions generally yield with the rest as do also indurated and inelastic tissues. After a free reparative circulation is established, the tumor usually becomes freely movable and later the uterus, which was held down by tumor weight and adhesions, may resume a normal position, to which it naturally inclines (9). This has occurred often enough so that we now entertain a reasonable hope for that result. The reduction of adhesions was one of the earliest observations made by the earliest x-ray therapists.

General management includes attention to the individual needs and a flexible régime for the woman who does not conform to the general rule. In order to estimate what the rule may be, we have a large card printed with regard to convenience and precision of detail on which we record so exactly the technique of each treatment that today we can repeat in every respect a treatment given ten years ago today. On this card is also noted the results of the check-up examinations. If there is less improvement than there should be a search is immediately made to find why the stasis.

Improvement is very soon apparent in a well selected case, and errors in diagnosis are promptly discovered. After treatments are finished it is our practice to urge the patient to report periodically to her physician or to myself for the follow-up estimation of her condition. In this way only can we draw reliable conclusions and attain accuracy as to results. Because the above named details are so important, I object to a technician, untrained in diagnosis and in the requirements of these cases. He should not be put in full charge even though he is under the so-called "direction" of a physician who is himself often untrained in exact gynecologic estimation and in x-ray possibilities. We should remember that x-ray is at once the most dangerous and the most benign of all the therapeutic agents. Because of these discrepancies in management, x-ray as a remedy in women's diseases has not come into full recognition. It has been in this special field more neglected, more misunderstood and more trifled with than has any other scientific measure.

Doubtless questions have arisen in your minds in the course of this paper. Some of those commonly asked I shall now endeavor to answer.

Q. Why are not normal tissues injured while pathologic tissues are remedied? Ans. They should not be if x-ray is not given too long and too strong. They are not changed during a brief application and with the low voltage technique because the pathologies we have discussed are all influenced by smaller doses than are muscle, nerve and other tissues (10).

Q. Is there not danger of x-ray burns? Ans. There is, always. But if in ten and one half years we have managed to avoid burns and other accidents, it follows that it can be done. It is, however, the one thing that makes x-ray therapy a most exacting business. In each of the ten cases of x-ray burns that I have known about in outside laboratories there was either ignorance or carelessness or a gambler's disposition to take chances.

Q. Does x-ray affect a woman sexually? Ans. It does not, under moderate application, if treatments are ended when the work is done. My women are, in a large majority, unchanged in this respect, except for the better. This is

the result of improved health and freedom from pain and discomfort during coition. The results are better under moderate x-ray than from radical surgery. Bride, of London, reports that 39 per cent of his operated cases are disturbed as to sex relations (11). Fear and psychic instability here enter into the problem, and these are favorably influenced if a woman knows that her generative organs are intact, as after x-ray.

Q. Is the danger of cancer greater if the pathology is not removed surgically? Ans. No. This fallacy should have been exploded long ago. During my ten and a half years only one died of cancer and that was seven years after treatment. Throughout the world of x-ray therapy there is the belief that x-ray helps to prevent cancer by relieving the precancer pathology and by the return of normal circulation. Franque, the famous x-ray therapist of Paris, reported 200 cases of fibroid with one cancer following (12). According to accepted statistics, he was entitled to six. The same is true of my own series.

Q. Why do you prefer x-ray to radium or surgery? Ans. I do, in selected cases only. When I get a case suitable to x-ray I prefer it for the following reasons:

1. There is no danger to life. Both radium (13) and surgery have an admitted mortality.

2. X-ray requires no loss of time, no hospitalization, and is therefore less expensive.

3. X-ray covers a wider field, includes more possible outlying pathology, stimulates more actively circulation of lymph and blood.

4. X-ray more easily reduces the large tumor than can radium.

In closing I wish to urge that Time and Nature are two almost invincible allies; that x-ray in remedial doses, not destructive doses, reduces the pathology and the adhesions, establishes a free circulation—after which more treatment is not often required; that health is conserved by methods free from shock and prostration and by leaving a woman's pelvis intact and functioning if possible; that the universal acceptance of x-ray depends upon an accurate

estimation of the case before, during and after treatment, careful records, a cautious disposition and a less amount of x-ray rather than more.

REFERENCES.

(1) Newcomet, William S.: Jour. A. M. A., Nov. 7, 1925.

(2) Knox, Lelia Charlton: Med. Woman's Jour., Oct., 1925.

(3) Pfahler: Jour. A. M. A., 1914.

(4) Nemenoff, Petrograd: Trans. Am. Jour. Roent., 1916; Bordier, Paris: Jour. A. M. A., 1911; Pfahler: Jour. A. M. A., 1914.

(5) Corscaden: Am. Jour. Obst., 1916; Kelly and Burnam: Jour. A. M. A., 1914.

(6) Simon, Herman: Trans. from the German, Am. Jour. Roent., March, 1916.

(7) Béclère: Trans. from Arch. d'electric Med., etc., Bordeaux, Dec., 1922, p. 257.

(8) Geist, Samuel H.: Mt. Sinai Hosp., Surg., Gynec. and Obst., June, 1922; Surg., Gynec. and Obst., March, 1923.

(9) Graves: Gynecology, 1916, p. 394.

(10) Seitz, Wintz and Wetterer: quoted by I. Seth Hirsch, N. Y. Med. Jour., Aug. 16, 1922, and Med. Record, July 19, 1922.

(11) Bride, J. W.: Jour. Obst. and Gynec., British Emp. Abstracted Jour. A. M. A., July 29, 1922.

(12) Franque: Medizinische Klinik, June 25, 1922. Abstracted Jour. A. M. A., Sept. 9, 1922.

(13) Graves: N. Y. Med. Jour., June 5, 1920, p. 969.

DISEASE IN PLANTS—A COMPARISON WITH HUMAN DISEASE.

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Although Phytopathology as a separate branch of study in our universities is a comparatively recent acquisition, the history of the study of plant diseases takes us back through the days of superstitious and religious beliefs to the very beginning of man's civilization. With his very earliest attempts at growing plants for his own use, man must have observed the appearance of disturbances in their growth and productivity for the very earliest writings mention the visitation of various plagues. These were considered to be sent by the gods and early offerings were made to the gods to propitiate them and get them to protect the crops.

The Bible makes mention of such maladies as blightings, rusts, mildews, and blastings and considers that they were laid down, like the boils of Job, as an expression of the wrath or disfavor of the Deity.

Among the greatest of ancient botanists was Theophrastus (372-287? B. C.) of Greece, a pupil of Aristotle. He accurately observed in his *Historia Plantarum* that cultivated plants were more subject to disease than wild ones. "As to diseases," says he, "they say that wild trees are not liable to diseases which destroy them. Cultivated kinds, however, are subject to various diseases, some of which are, one may say, common to all or to most, while others are special to many kinds. General diseases are those of being worm-eaten, of being sun-scorched, and rot.

"The olive in addition to having worms (which destroy the fig, too, by breeding in it) produces also a knot (which some call a fungus and others a bark blister) and it resembles the effect of sun scorch. The fig is also liable to scab. Moreover, there are certain affections due to season or situation which are likely to destroy the plant, but which one would not call diseases; I mean such affections as freez-

ing and what some call 'scorching.' As to diseases of seeds —some are common to all, as rust, some are peculiar to certain kinds." Theophrastus seems to have made rather a careful study of the epiphytotics of rust as they occurred in Greece.

The true etiology of disease in plants in these ancient days was, for the most part, buried deep in the mystery and superstition from which it was a long time in being extricated. Legends were evolved to explain the maladies and diseases were dedicated to special gods, such as the Roman rust gods, Rubigus and Rubigo, in whose honor annual festivals of propitiation were held.

From 476 A. D. to the beginning of the seventeenth century, which includes the "Dark Ages," was a dark age for Phytopathology too, but interest was revived in the seventeenth century, this time among the farmers and agriculturists, whereas previously it was the philosopher who speculated on the cause of disease while the superstitious farmer offered up libations to the gods. (We still have some farmers who plant certain crops by the dark of the moon.) It was during this century that the first law, so far as record shows, was enacted for the express purpose of controlling a plant disease. In Rouen, France, in 1660, a decree was passed directing the digging up and destroying of all barberry plants. The barberry was thought to bear some mysterious relation to the wheat-rust epiphytotics. It is a striking thing how often the observations and, one might almost say, "hunches," of these early observers came very near hitting the truth, as was the case in this first "barberry eradication campaign."

The eighteenth century was a period devoted to taxonomy-attempts to name and classify the diseases on a symptomologic basis. The names were fashioned after or copied from those used for supposedly similar human diseases. Thus we have plant cancers, tumors, fevers and so forth. Johann B. Zallinger in his book on plant diseases, 1773, divided plant diseases into (1) Phlegmasiae or inflammatory diseases, (2) Paralysis or debility, (3) Discharges or draining, (4) Cachexia or bad constitution, and (5) Chief defects of different organs.

It must be remembered that all during this time any fungi found associated with disease lesions were considered

not as causes of the disease but as abnormal structures resulting from the disease—that is, morbid plant tissues. Although more emphasis was now laid on the causal nature of such environmental factors as droughts and freezing, the etiology of plant diseases was still largely assigned to supernatural forces. There was an occasional leaning toward the autogenetic theory of disease, the plant being considered to have within it a disposition to disease. Unger (1833), a strong advocate of the autogenetic theory, believed that fungi originated from the diseased host tissues but still he recognized them as distinct organisms worthy of names and classification. He believed diseases were brought about through internal disorganization of the nutrition processes, having their origin in a lack of certain chemical constituents of the sap. The fungi, or entophytes as he called them, were the transformed sap of these diseased tissues, the morbid sap being exuded into the intercellular spaces and there converted under the influence of the still living cells of the host into fungus structures.

During the latter part of the eighteenth century and the early part of the nineteenth, further studies on the part of the growing school of mycologists resulted in the recognition of the independent nature of the entophytic fungi which were found to propagate their kind by means of the spore-like structures or reproductive bodies. It then followed that the organisms must be the causes of the diseased conditions with which they were associated rather than the result. The theory was upheld by such men as De Candolle, Link and Tulasne, but there was up to this time no carefully checked infection experiments to prove it. The first positive proof of the causal relation of an organism to a plant disease was brought out by a young German botanist, Anton de Bary, who was trained in medicine but after practicing two years gave up medicine for research in Botany.

In 1853, just seven years before Louis Pasteur presented to the Academy of Science his first work upsetting the spontaneous generation theory, De Bary published his classical work, "Die Brand Pilze," establishing unquestionably the causal nature of the fungi found associated with rust and smut diseases. Previous to this time, 1844-45, the eyes of everyone were turned upon the economic importance

of plant diseases through the widespread and disastrous epiphytotic of the Phytophthora late blight which devastated the potato fields of Europe resulting in famine in some regions. De Bary worked out and published in 1861, the nature of the late blight and the causal relation of Phytophthora infestans.

Just previous to this, in 1858, the farmer scientist, Julius Kuhn, published his famous phytopathologic text—the first to appear based on the remarkable discoveries and researches of De Bary, Pasteur and the others of that school.

It is an interesting little side line, that an appendix in the book was entitled, "The Microscope as a household utensil for the farmer."

Perhaps the last great stage in the development of phytopathology as an independent field of work was ushered in by the discovery of Bordeaux mixture in 1883, and the subsequent emphasis placed upon the economic features of plant pathology. Like Dr. Arno B. Luckhardt's discovery of the anaesthetic property of ethylene gas, and many other discoveries far reaching in their effects, the fungicidal properties of Bordeaux mixture were learned quite by accident. Millardet, a young Frenchman was another physician who abandoned medicine for the pursuit of botany. While attempting to devise control measures with which to combat the devastating spread among the wine grapes of an introduced American fungus causing mildew, he accidentally observed the prophylactic effects of a mixture of copper sulfate and lime which had been sprinkled on grapevines near the road to prevent stealing of the fruit. He at once undertook the investigation of copper as a fungicide and developed the Bordeaux mixture which has been so efficiently and universally used since.

The most important event in the rise and development of phytopathology in this country was the establishment in 1885 of a section of Mycology of the Botanical Division of the United States Department of Agriculture. F. Lamson Scribner was appointed as mycologist and the following year Erwin F. Smith, later so well known for his work on Plant Cancer, was called to be his assistant. Since their work had mostly to do with diseases in plants the name of this section was changed in 1887, to that of Vegetable

Pathology. From a union of this section with four other divisions arose the present Bureau of Plant Industry.

Such has been the history of Plant Pathology, slower in its earlier development than the history of medicine, but rather quickly springing to maturity after the world became convinced of its practical nature in meeting the needs of plant-eating, wearing, and sheltered man.

And of practical value it surely is, for there is not a cultivated plant which is not subject to several diseases, nor does one find that the wild plants are immune to all the rusts, smuts, leaf spots, and pests in general that prey upon plant tissues. Just what is a plant disease and do they have diseases just like humans? is a question a plant pathologist is often called upon to answer. Perhaps the hardest part of the answer comes in the question "what is disease?" for the line between disease and health is sometimes a very narrow one, especially when nothing more is involved than some slight change in function.

It is evident that the concept, "disease," cannot mean just the same to the medical doctor as it does to a phytopathologist for the very reason that man sets himself up as a judge of what health in plants shall consist of. When the medical doctor visits the bedside of another human who claims to be sick, the patient considers that he is himself the best judge of whether or not he is in good health. Unfortunately, for its own complete life functions sometimes, the plant is not able to state its views on the matter. We do not consider that the lovely white bordered coleus leaves are diseased, yet further loss of the same green pigment has reduced some plants to parasitism, and when such light areas show up in mosaicked potato-plants we are immediately alarmed. In both cases the nutritional processes of the plant have been diminished. The farmer has learned to know how beneficial to him is the presence on the roots of his clover and alfalfa of the little tubercles inhabited by nitrogen-fixing bacteria and would probably laugh to scorn any suggestion that the roots were diseased. Yet a hand as warty as the alfalfa roots is certainly considered pathological.

The cauliflower developed under cultivation has its normal flower shoots compacted and aborted and so enlarged that they form a fleshy edible mass whose normal

function of producing seed is completely interfered with. A quite different looking plant, this horticultural variety, from its ancestral plant Brassica oleraceae, variety sylvestris, still growing wild on the seashores of western and southern England and Europe. The ancestor at beholding the cauliflower or those other wayward brothers,—the Brussels sprouts with its multiple heads, and the kohlrabe with his goiterous neck—would probably (were it given the power of expression) throw up its branches and exclaim in holy horror, "Look what the association with these wicked men in cities has done for my poor children! Why didn't they stay at home on the seashores of the old country as any self respecting Brassica plant should do?" One might well regard the changes which have taken place in the cauliflower under cultivation as pathological. Certainly from the plant's point of view they are. However, any tendency in the cauliflower to revert back to its ancestral type and function correctly would be viewed with concern and considered pathological from the view-point of man. A plant disease is usually considered, then, as any marked deviation from the normal functions or structure of the plant as it *now* exists, whether wild or greatly modified by cultivation—any deviation which involves death or impairs the life or economic value of the plant.

Various factors are responsible for a difference in the nature of disease in plants and animals. A closed circulatory system and an intricate nervous system in animals results in more systemic diseases. The nearest approach to the circulatory system in plants is the vascular system which is not a connected system of veins offering free circulation to all parts of the plant body as in the case of the human circulatory system. There is no demonstrable nervous system, the most nearly comparable thing being the very fine cytoplasmic strands passing from one cell to another. Hence diseases in plants are more apt to be local as in Nailhead spot of tomatoes, than systemic as in loose smut of grains. In loose smut of grains the organism (Ustilago) gains entry to the young seed and penetrating the ovary wall lies dormant in the embryo. When the seed germinates the resulting dwarfed plant harbors the parasite which keeps pace with the growing point till time for flow-

ering and is therefore in the new seed which becomes a mass of loose smut spores scattering to new plants.

Plants are more at the mercy of the environment than humans are, which again affects the nature of disease in the two. Man being a warm blooded animal is not submitted to the vast temperature range to which plants are exposed. A circulating blood stream, respiratory activities with the giving off of heat in warmed air, involuntary muscular reactions such as shivering, and the giving off of sweat from the body surface all combine with the radiation from the skin itself to keep uniform the bodily temperature of man, even were he not able to move to new environment or to put on or remove clothing at will. Plants on the other hand are fixed in their environment, and are able only by transpiration and radiation to cut down the temperature in summer and by a slow chemico-physical process to harden themselves to extreme temperatures in winter. With a weather as fluctuating as that in Chicago where there can be a daily range of over 40° between maximum and minimum, it is not surprising that the plants are often caught with a lowered resistance. Non-parasitic diseases due to hot winds, freezing temperatures, or excessively high temperatures, unfavorable light relations, and unfavorable soil and atmospheric water relations are very common in the plant world as may be evidenced by the common appearance of sun scalds, sun burns, blastings, waterloggings and like symptoms, as contrasted with the occasional sun stroke, heat-exhaustion and frosted ear occurring among humans.

Plants also lack the elaborate defense mechanism against the invasion of organisms. The lacunae of the tonsils are veritable culture basins for numerous streptococci and other bacteria, but these are kept at bay not only by the epithelium but by an army of bacteria-destroying-leucocytes which constantly stream out from the lymphoid tissue. A plant has no such army for self protection. If the skin of the leg or arm is broken through accident and the injured area becomes infected with streptococcus or staphylococcus, a protective mechanism is at once activated to keep it local. An acute inflammation occurs with dilatation of the blood vessels, increased blood flow, exudation of serum and leucocytes and increased local heat. A wall of leucocytes about the inflamed area limits the spread of

the infection. If, on the other hand, the plant loses its protecting cutinized layer by trauma and the parasite gains entrance there is no resultant releasing of a host of little bacteria-digesters, no production of a hostile temperature.

If the plant does not succeed in laying down a corky protective layer and forming wound tissue, and if its protoplasm does not contain a substance toxic to the invading organism, it has no further recourse. Cells may die over a large enough local area to check further advance by starving out the invader.

This leads us rather nicely to a comparison of immunity in plants and animals. Humans may possess a natural immunity, as is true of the most of us in the case of tuberculosis, or an acquired immunity as in the case of those people who have once had scarlet fever and are therefore free from its infection. Plants have natural immunity only. There are some few reported cases of acquired immunity in plants, but none of them have held up under tests. Immunity in plants is mostly a matter of genera, one genus being free from a disease while another is susceptible. Much use of this fact has been made in the breeding of disease resistant strains. Resistant strains are the only hope to the farmer in the case of such diseases as cotton and melon wilt which are caused by species of Fusarium, an almost ubiquitous soil parasite. Pioneer work in the breeding of disease resistant strains was done by W. A. Orton of the Bureau of Plant Industry and great steps are being made along these lines at the present time.

Some of the essential differences in principle between diseases of plants and those of man have been brought out, but in many essentials diseases in the two are very similar.

The response of plant cells to a pathological stimulus is in many ways like that of the cells of the human body. There may be a qualitative change in the cell or the response may be of a quantitative nature such as decreased photosynthetic activity or increased mitotic activity. The response of the cells may be one of hypoplasia, as in nanism, the cells becoming smaller or failing to reach their normal number. Such a response is exhibited by pot bound plants and is made use of economically by florists in producing small evergreens for decorative purposes.

Or the cells may be stimulated to excessive division resulting in hyperplasia. This may or may not be accompanied by hypertrophy, or the enlargement of cells already present. Both symptoms are exhibited in peach leaf curl which is one of the most serious diseases affecting fruits in cooler climates. The physiological pathology involves hypertrophy and hyperplasia, chlorosis, necrosis and dropping of the leaves with subsequent loss of vitality due to defoliation and development of new leaves.

Metaplasia such as is exhibited in the bronchi of the human lungs when the high columnar epithelium cells are changed to stratified squamous cells, is seldom if at all exhibited in plants. The nearest phenomenon is the stimulation of the cambium to form cortical tissue instead of phloëm as in club root of cabbage. Finally, the stimulus may result directly in morphological, physical or chemical disorganization with local or total necrosis. Most of the leaf spot and fruit spot disease are examples of local necrosis.

The effect of the parasite on the host is accomplished by toxins as in some Fusarium wilts, enzymes as in slimy soft rot of vegetables, or less frequently by mechanical trauma, as in Albugo which causes excessive contortion of its host as well as loss of food. The parasite may interfere directly with the food supply of the plant much as the tapeworm does in man, or it may fill the vessels as in Fusarium wilt and thus cut off the transfer of water and soil solutes.

As in animals, so in plants physiological predisposition seems to play a certain part in the development of disease. Just as in tuberculosis, race is an important influence, the disease seeming to be particularly fatal to negroes, so there is a racial predisposition in plants. Black rot, caused by Pseudomonas campestre, is confined entirely to plants of the mustard family. Age is also an important factor, onion smut occurring only in young tissues. There are some fungi which are known definitely as seedling blights.

Sex influence is demonstrated in the limiting of ergot of rye to the ovary. In man certain diseases may be confined to one system or even to a part of one system, as in the confinement of Tabes dorsalis at onset to the sensory tract of the nervous system. Similarly diseases in plants

may be confined to one system or to one organ. Potato wart attacks only the tuber of the potato.

As to the *causes* of plant disease—one might divide plant diseases much as Osler does in his text book, into (1) specific infectious diseases, (2) diseases due to physical agents, (3) intoxications, (4) deficiency diseases, (5) diseases of metabolism.

In the case of plants most emphasis would be laid on the first of these, a great deal more emphasis laid on the second than in the case of animals, and least emphasis put on intoxications. Apple scald may be considered as an intoxication. It occurs on apples in storage and seems due to the accumulation in the air surrounding the apples of the odorous substances given off by the apples in their respiration (amyl esters of formic, acetic and caproic acids). It is prevented by wrapping in oiled papers which absorb these odorous substances.

More specific infectious diseases of plants are caused by fungi than by any other group of parasites. Practically every taxonomic group is represented among the disease formers. Some fungi are strictly parasitic as in the case of the wheat-rust, some are either parasitic or saprophytic which is true of that widely known soil fungus and decay producer—Fusarium. Some of the fungous diseases have reached national importance, for instance, the chestnut blight and the white pine blister rust which have spread rapidly with serious effects.

There are many cases of plant injury due to metazoan parasites. Common among these are the nematode disease of roots of various plants (root-knot caused by Heterodera radicicola), and bulb and stem infections due to species of Tylenchus. The oriental fruit moth causes injury in peaches and apples and the codling moth is responsible for an injury to apples. The striped cucumber beetle and his little friend of the polka dotted uniform, Diabrotica duodecipunctata, feed upon the leaves and young stems and cause much damage to the cucumber vine. Plants like humans are subject to lice, though lice are a little more prevalent among the plant aristocrats such as the Rose family than is true of man.

There is no proven case of protozoan infection in a plant though the connection of amoebae with the disease known as mosaic has caused considerable discussion in the past few years. Holmes of the Boyce Thompson Institute has definitely proven the existence of Flagellates in the latex tissue of Euphorbia. Living protozoans have been isolated from tobacco plants showing mosaic symptoms but the tendency of investigators now is to discount any causal relationship of the protozoans found to the mosaic disease. Mosaic seems doomed to be classed with measles and smallpox as a virus disease of doubtful or unknown etiology for yet some time.

Through the relative importance of bacterial diseases and fungous diseases is reversed in plants as compared with animals still some of the most interesting and very important plant diseases are due to bacteria.

An American, Thomas Jonathan Burrill, working at the University of Illinois deserves the credit for the discovery of bacteria as a causal agent in plant disease. Burrill was working on fireblight of apples and pears. The causal organism, Bacillus amylovorus, which is motile by peritrichiate flagella, first destroys the blossoms, green fruits and young shoots but passes quickly downward by way of the bark parenchyma into the larger branches and trunk often girdling and killing them.

The common symptoms are wilting and blackening or browning of the blighted twigs or branches, the dead persistent leaves of which look as if they had been scorched thus giving rise to the common name for the disease—fireblight. The death of so many twigs results in a forcing of adventitious buds to form new shoots. The fruit becomes water soaked and later the tissues darken and become soft at the center with yellow honey-like horns, oozing out thru the lenticels. As the inner bark of the shoots becomes firm in late summer, the blight seems to spread, and the organism usually dies off over winter. But in some cases "hold-over-cankers" are formed from which, with increased sap flow in the spring, ooze out living and virulent bacteria.

It is an interesting fact that the role insects may play in the transmission of disease was first clearly proved in connection with fire blight though the connection of mos-

quitoes with malarial fever was an old story suggested as far back as Roman times. Merton B. Waite's first report on the role of insects as a carrier of the fireblight organism was made to the American Association and published in the Botanical Gazette in 1891, two years before Smith and Kilborne showed that the cattle tick acted as an intermediate host in the case of Texas cattle fever and several years before Ross' work (1895-7) on the connection of mosquitoes with avian malaria. This latter work stimulated the investigations which resulted in the discovery of the relation the Anopheles mosquito bore to malarial fever.

Waite found that insects carried the bacteria from the amber fluid extruded from the hold-over cankers in the spring to the flowers where a short incubation followed, the bacteria multiplying rapidly. Infection occurs by penetration of the nectary, and from here the bacteria work their way thru the fruit spur at whose base a small canker may form. The secondary cycle is the one most responsible for serious damage. The infected nectaries act as sources of inoculum from which the nectary visiting insects such as bees carry the bacterium from one flower to another. The disease may also be carried by sucking insects such as the aphid and leaf hopper, these latter being responsible for infection of many of the new and succulent shoots formed from adventitious buds.

Fire blight is one of the few plant diseases in which therapeutic measures may be taken since eradication of the cankers by tree surgery and systematic cutting out of blighted twigs is as necessary as the removal of a gangrenous area in humans. Most of the diseases of plants must be fought with prophylactic measures.

In concluding we may say that while plant diseases are, by virtue of the difference in nature of the human body and that of the plant, different in some ways, there are the same general types of response to the presence of a parasite, and plants are subject to the same types of pests. As to whether the same organism can create disease in plants and in animals little is known. J. R. Johnson working in Smith's laboratory found an organism causing coconut bud rot in the West Indies which was indistinguishable from Bacillus coli. Cross inoculation studies have been

made with plant parasites in animals and animal parasites in plants but the results may be summed up as being doubtful or negative. However, M. Downin recently reported an interesting case of food poisoning in Russia. Rye grains infected with Fusarium roseum. Lk. are responsible for what he calls "inebriant bread". People who ate it suffered from weakness, vertigo, headache, nausea and vomition. He also isolated a species of Fusarium from the flax which was used in making "inebriant" linseed oil in Ukraine. This furnished the same symptoms as the rye.

Literature Cited.

1. de Bary, Anton: Untersuchungen über die Brandpilze und die durch sie verursachten Krankheiten der Pflanzen, mit Rucksicht auf das Getreide und andere Nutzpflanzen, pp. I-VII-1-44, Berlin, 1853.
2. ——— ——— Die gegenwartig herrschende Kartoffelkrankheit, ihre Ursache und ihre Verhütung, pp. 75, Leipzig, 1861.
3. Burrill, Thomas J.: Series of papers presented before the Illinois Horticultural Society, 1878-84. For complete list see bibliography in New York (Cornell) Agr. Exp. Sta. Bul. 329:369, 1913.
4. Dounin, M.: The fusariosis of cereal crops in European Russia in 1923. Phytopathology, Vol. 16, No. 4, 305-8, 1926.
5. Hort, Sir Arthur: Theophrastus' enquiry into plants. 1:I-XXVIII, 391-413; 2:I-IX—201-209, 1916.
6. Holmes, F. O.: A flagellate infection of milkweed in Maryland. Abstract, Phytopath. Vol. 14, No. 1, p. 54, 1924.
7. Johnston, J. R.: Coconut budrot of the West Indies, Phytopath. Vol. 1, No. 3, 1911.
8. Kuhn, J.: Die Krankheiten die Kulturgewachse, ihre Ursachen und ihre Verhütung, pp. I-XXII-1-312, Berlin, 1858.
9. Luckhardt, A. B. and J. B. Carter: The physiologic effects of ethylene. A new gas anesthetic. Journ. Amer. Med. Assoc., Vol. 80, pp. 765-770, 1923.
10. Millardet, P. M. A.: Annales de la Societe d'Agriculture de la Gironde, 1885, p. 73.
11. Osler and McCrae: The principles and practice of medicine. D. Appleton & Co., N. York, 1923.
12. Orton, W. A.: Plant breeding as a factor in controlling plant diseases. Amer. Breeders' Assoc., 1:69-72, 1905.
13. ——— ——— The development of disease-resistant varieties of plants, IV Conférence Internat. de génétique, Paris, 1911 et al.
14. Ross, R.: The Role of the mosquito in the evolution of the malarial parasite. The Lancet, Vol. II, p. 488, 1898.
15. Smith, E. F.: Bacteria in relation to plant diseases, Carnegie Inst. Publication, Wash. D. C., Vol. I, 1905; Vol. II, 1911; Vol. III, 1914.
16. ——— ——— Crown gall of plants, its cause and remedy, U. S. D. A. Bu. Pl. Ind. Bul. 213, 1911.
17. ——— ——— Crown gall and sarcoma, U. S. D. A. Bu. Pl. Ind. Circ. 85, 1911.

18. ——— ——— Embryomas in plants (produced by bacterial inoculations). The Johns Hopkins Hospital Bull. 28:276-294, Sept., 1917 et al.
19. Smith, T., and F. L. Kilborne: Investigations into the nature, causation and prevention of Southern cattle fever, Bur. of Animal Ind. Rept. 177-304, 1893.
20. Vallery-Radot, R.: Life of Pasteur, Doubleday Page and Co., 1923.
21. Waite, M. B.: Fire Blight of Pears, Proc. Amer. Assoc., 1891, p. 315 & Bot. Gaz., 1891, p. 259, under Bot. Papers at the A. A. A. S.
22. Whetzel, H. H.: An outline of the history of phytopathology, W. B. Saunders, 1918.
23. Zallinger, J. B.: De morbis plantarum cognoscendis et curandis dissertatio exphaenomensis deducta, 1773, German trans. by J. G. von Auersberg under title Abhandlung über die Krankheiten der Pflanzen, ihrer Kenntniss und Heilung; aus dem Lateinischen ubersetzt, pp. I-VI-1-143, Augsburg, 1779.

SOME ASPECTS OF CHLORINATION CONTROL IN CHICAGO.

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Read before the Medicine and Public Health Section of the Illinois State Academy of Science, Joliet, Ill., April 30, 1927.

In Chicago as chlorination is the first and only line of defense against a more or less dangerously contaminated public water supply, unusually rigid supervision is maintained over this and other measures directed toward safeguarding the water. Chicago conditions are not only different from those in other cities, because of the limited time available for treatment, but also the magnitude of the chlorination program is quite beyond that of most public water supplies on account of the quantity of water which is pumped. Because of these conditions much has been done, particularly during the last three years, towards improving and standardizing chlorination control work.

The water supply of the City of Chicago is obtained from Lake Michigan through six intake cribs located along the lake front from two to four miles from shore. The water taken in through the intakes passes down through a shaft to a tunnel, which conducts it to a suction well under each of the ten pumping stations, from which it is pumped directly into the distribution system. The chlorine used for disinfection is applied to the water in the suction well at the pumping station. The average daily pumpage for the entire city during 1926 was 878 million gallons. The average quantity of chlorine used for disinfection was 3.56 pounds per million gallons.

There are three fundamentals in connection with the chlorination of Chicago's water supply which are given careful attention:

1. The chlorine must be applied uniformly and continuously to the water pumped.

2. There must be good diffusion of the chlorine solution in the water being treated.

3. The quantity of chlorine applied must be adequate for positive disinfection.

To assure uniform and continuous application of chlorine to the water the City of Chicago employs a corps of 35 chlorine attendants whose duty is to attend to the operation of the chlorinating equipment and to make the necessary control tests. During each of the three eight-hour shifts at the ten pumping stations a chlorine attendant is on service. It is his duty to operate the chlorinators so as to apply the prescribed quantity of chlorine in proportion to the rate of pumpage, making an hourly check on the quantity delivered by the chlorinators by determining the loss of chlorine from the batteries which are mounted on weighing scales.

The chlorinators used at the pumping stations now in operation are of the manual type, it being necessary for the attendant to make adjustments to compensate for normal variations in the rate of pumpage and those resulting from the stopping and starting of the different units. The plans for the new Western avenue pumping station, which will be put into operation this summer, call for automatic chlorinators. This type of apparatus delivers the prescribed quantity of chlorine it is set for in direct proportion to the rate of pumpage, by means of control mechanism connected to the venturi meters.

While it is highly important that there be uniformity in the rate of application of chlorine to the water from minute to minute and hour to hour, to avoid tastes due to periodic over-dosing, it is imperative that the application of chlorine be continuous. To assure uninterrupted chlorinating service Chicago has taken unusual precautions. In each pumping station there is sufficient chlorinating equipment to deliver the maximum quantity of chlorine considered necessary at the maximum rate of pumpage for that station. In addition, there is in reserve a complete duplicate set of equipment. Each group of chlorinating units is set up in a special booth with all chlorine lead lines in duplicate and inter-connected. Duplication of booths was decided upon as chlorine is a dangerous gas and in order that operation from one booth might be carried on in case of an accident in the other, making it impossible for the operator to enter. Each booth is connected with a special exhaust system for discharging chlorine gas out of doors

when necessary and any employe whose duties require him to handle chlorine has a special gas mask for emergency service. Under normal operation the City has nearly 200 per cent stand-by chlorinating equipment available for service. Although a considerable initial outlay was necessary to provide Chicago pumping stations with this chlorinating equipment, the expense was amply justified. The average cost per capita for safeguarding Chicago's water supply by chlorine is approximately five cents per year, an exceedingly low charge for health insurance.

Under Chicago conditions it is very important that the chlorine be thoroughly diffused in the water before the latter is delivered to the distribution system. This is necessary not only for effective disinfection, but to prevent excess chlorine in the water drawn into one pump with a corresponding under-dosage in the other. The depth of the suction wells in the Chicago system varies from 30 feet to over 100 feet, with usually from two to four pumps supplied by a common well. To avoid short circuiting of chlorine to one or more pumps of a group drawing on a single well it is necessary to apply this sterilizing solution at a sufficient depth in the well to assure complete diffusion before the water reaches the pump suctions. Studies made in 1924 indicated quite clearly that in many instances complaints of excess chlorine in the water were due to short circuiting of this nature. Our experiments indicate that to assure complete diffusion the chlorine should be applied to a depth of at least 30 feet below the pump suction and preferably 50 feet. It is our policy to apply the chlorine at the eye of the incoming tunnel if possible, using rubber hose encased in pipe conduits attached to the shaft wall. To avoid collapsing of the solution hose due to the long down draft of the chlorine solution, they are vented near the top of the wall.

Having perfected arrangements for a uniform and continuous application of chlorine with complete diffusion in the treated water, it is, of course, necessary that the quantity of chlorine used must be adequate for efficient disinfection. Investigators differ widely in their claims for the amount of chlorine required to kill pathogenic organisms. This is partially due to the lack of definite informa-

tion concerning the action of chlorine on these organisms as well as the concentration and time necessary for sterilization. Pending more definite information on this subject those of us who are charged with the responsibility of safeguarding a public water supply must be guided by our own experiences and the results of bacteriologic examinations of samples of the chlorinated water. In Chicago at certain seasons of the year, especially late winter and early spring, the bacteriologic control is frequently interfered with by the presence in Lake Michigan of non-confirming gas formers which seriously affect the reliability of the presumptive tests for B. coli.

Where the bacterial contamination of the sources of supply varies widely and frequently abruptly, a correspondingly wide margin of safety must be maintained, with the result that often greater quantities of chlorine are used for disinfection than would be necessary if the bacterial load was more uniform. It is fundamental that sufficient chlorine be present in the water to satisfy the demands of organic matter that may be present lest that available for disinfection be inadequate. Since the time interval for killing pathogens by chlorine has not been established it is common practice amongst water purification engineers to carry slight quantity of chlorine in the treated water for a period of at least five minutes after application of the sterilizing agent. In Chicago we make a practice of carrying at least one pound per million gallons residual chlorine in the water as discharged from the pumping stations. Each hour throughout the day and night the chlorine attendant makes a test for free chlorine, using orthotolidin, and comparing the intensity of the color with that of known standards. In case there is excessive absorption of chlorine, as occurs not infrequently at the South Side stations following southerly winds, the operators are authorized to increase the quantity of chlorine until the specified amount of residual can be carried. This frequently requires the application of chlorine in amounts double and even triple the average. The fact that "slugs" of grossly polluted water may be received suddenly at a station makes even the hourly residual chlorine test subject to an element of uncertainty, but it is not considered practical to make these tests

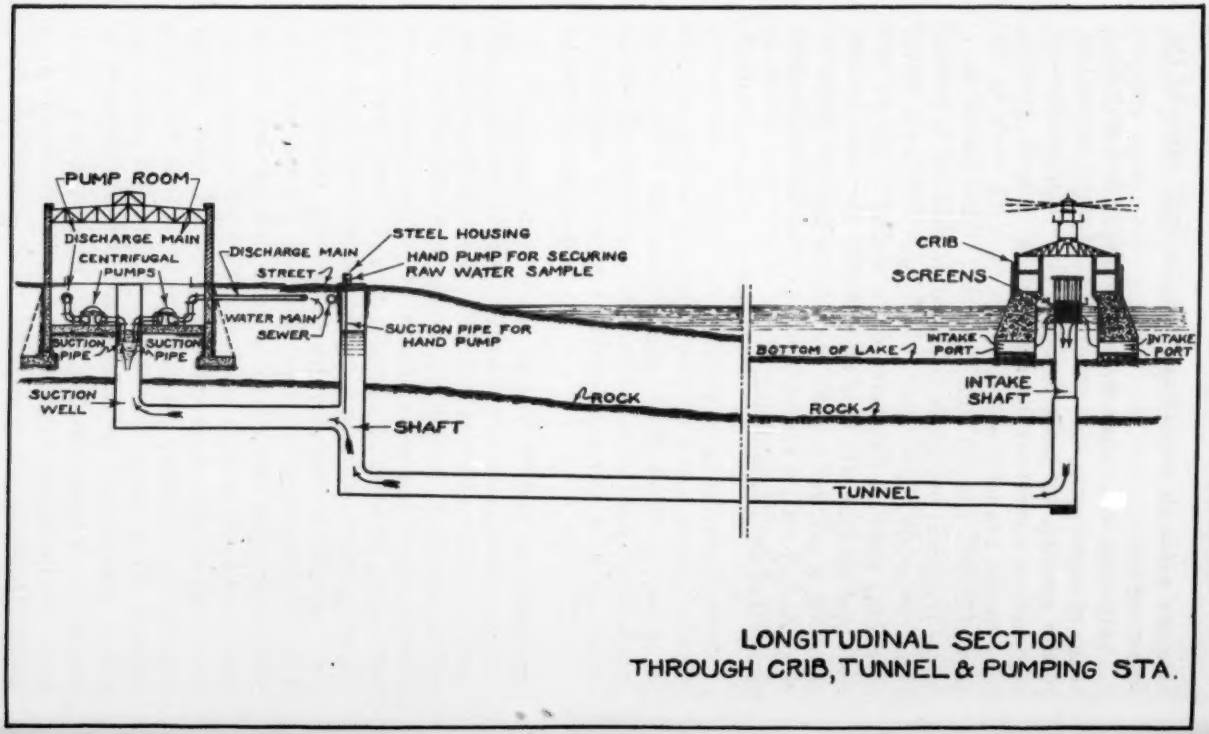
routinely at more frequent intervals. Under our present program approximately 220,000 residual chlorine tests are made at the Chicago pumping stations each year. During periods of high absorption, tests are made every 15 minutes, the operator receiving assistance at the time from other employes at the station.

The City is now arranging, through representatives of a large instrument manufacturing company, to conduct studies on apparatus which will automatically record the residual chlorine in the water at pumping stations. Equipment of this kind should supply the "missing link" in the chlorinating control of public water supplies. It does not seem beyond the realm of possibilities that this type of apparatus may even be developed to regulate the quantity of chlorin used so that a definite residual may at all times be maintained in the water supply. The successful development of such an apparatus will be a tremendous advance in the art of chlorination and should make it possible to reduce the safety margin now considered necessary where chlorination is the only treatment given a public water supply for disinfection.

The importance of the time of contact between chlorine and water for the sterilization of pathogens is an outstanding problem under Chicago conditions where the time interval between the point of application of chlorine in the suction well and the discharge to the distribution system may vary from 16 to 90 seconds. In order to protect the first consumers supplied by mains near the pumping station it is necessary to apply larger amounts of chlorine than would be used if a short storage period were available. Our studies indicate that there is a relatively rapid absorption of chlorine in the water circulated through the distribution system. Each day tests are made at various points in the system for residual chlorine, which indicate that with few exceptions, as in the case of service mains in the vicinity of pumping stations, the quantity of free chlorine in the water is relatively small. In general, there is no serious complaint of chlorine in the Chicago water at periods when Lake Michigan is not contaminated by industrial wastes such as phenols and cresols, which combining with the chlo-

rine gas gives an obnoxious "carbolic acid" taste in the water supply.

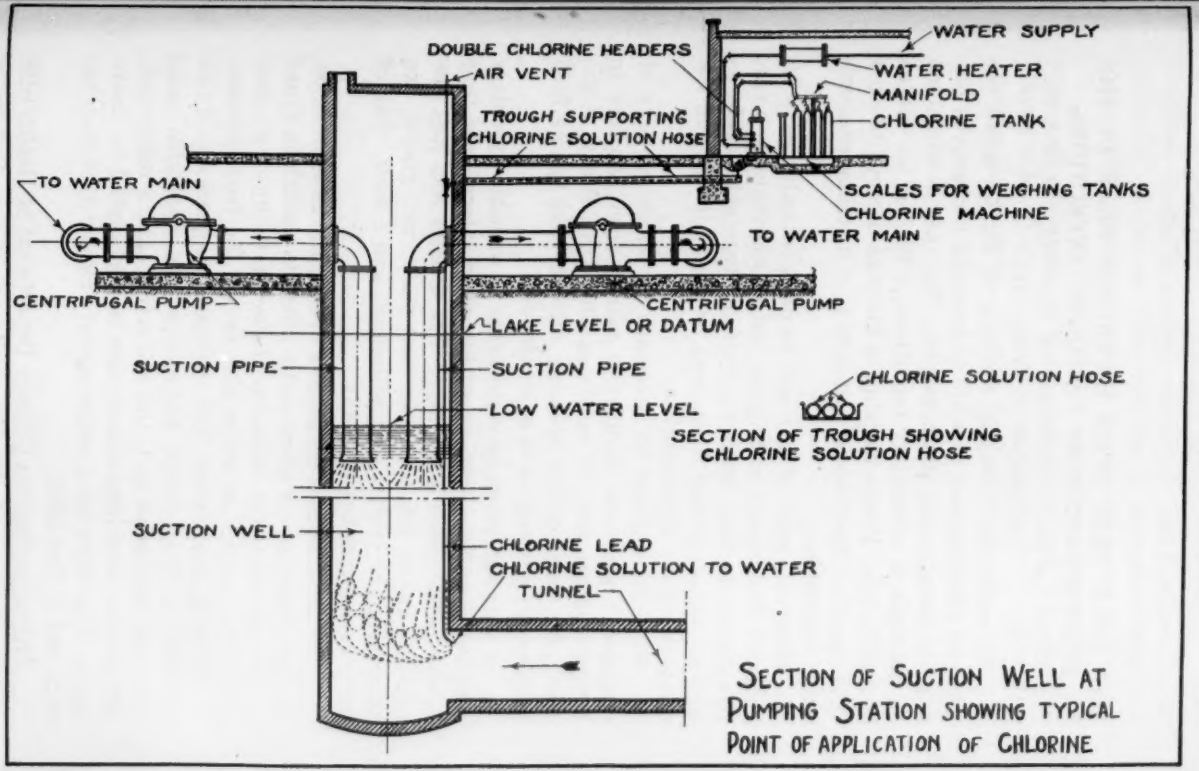
Although in Chicago we have probably had as wide a range of experiences with chlorination of water as any city in this country, we really feel that the water purification engineers are seriously handicapped by lack of scientific information available only through research work by the bacteriologist, chemist and physicist. Chlorination as a water treatment process is firmly established but in general is rather crudely controlled. Until such time as a better sterilizing agent is discovered or developed it appears evident that chlorine will have an extended use wherever disinfection is required and we are hopeful that the future in this line may attract research men to a service which offers so much of good to mankind.



LONGITUDINAL SECTION
THROUGH CRIB, TUNNEL & PUMPING STA.

THIS CHART WILL BE THE
SECOND CHART APPEARING
AT THE END OF THIS FILM

WATER SUPPLY



SECTION OF SUCTION WELL AT PUMPING STATION SHOWING TYPICAL POINT OF APPLICATION OF CHLORINE

THE ROLE THAT FOOD HANDLERS PLAY IN THE DISSEMINATION OF PARASITIC INFECTIONS.

BERTHA KAPLAN, UNIVERSITY OF ILLINOIS, COLLEGE OF MEDICINE, CHICAGO, ILL.

O'Connor and Wenyon working in Egypt found the greatest percentage of carriers of encysted Endamoeba histolytica among cooks and prisoners. This may be explained on the basis of unsanitary conditions of the soil as well as of institutions. People working in kitchens become infected with encysted Endamoeba histolytica by handling contaminated vegetables.

However, most of our soil is not contaminated with encysted Endamoeba histolytica, but should there be a carrier among the food handlers, fruit and vegetable salads, as well as various cooked foods, may be contaminated and the diseases readily disseminated.

While it may not be necessary to isolate carriers of encysted Endamoeba histolytica among food handlers in Egypt or other tropical countries where the disease is endemic, the necessity for isolating such carriers among food handlers in our region is quite obvious.

A year ago seven or eight cases of amoebic dysentery occurred simultaneously, or within short intervals of time in one public place in Chicago. The disease was well distributed among the people of that place: two guests, two housemen, one janitor, one policeman, and a cook. Two of those cases terminated fatally.

The simultaneous occurrence of so many cases of amoebic dysentery in one place under climatic conditions found in Chicago led to the suspicion of the possibility of the presence of a carrier or active case among the food handlers. A survey of the kitchen help disclosed the presence of two carriers of Endamoeba histolytica—one vegetable salad girl, one fruit salad girl, and one active case, a night cook. All of them were immediately sent to the hospital for treatment. Since then not a single case of amoebic dysentery has occurred in that place.

Following that the Chicago Department of Health with the cooperation of the University of Illinois College of

Medicine started a general survey of food handlers in all the hotels of Chicago, hospitalizing all carriers of encysted Endamoeba histolytica, as well as of hook-worm infections.

Not only is Endamoeba histolytica transmitted by means of contaminated food and water, but also Ascaris lumbricoides, Oxyuris vermicularis, Trichuris trichiura, frequently Ancylostoma, Nector, Strongyloides, etc.

MIGRAINE OR SICK HEADACHE.

A Sensory Disturbance Due to Protein Sensitization or Idiosyncrasy.

WILLIAM L. BEECHER, M. D., CHICAGO. ILL.

For the benefit of the non-medical portion of my audience I will state that the term migraine or sick headache is applied to a combination of symptoms of which the headache is only a part. There are frequently premonitory symptoms by which the patient knows an attack impends. Among these are flashes of light and other disturbances of vision. Dizziness occurs in some cases. Palpitation of the heart at times precedes the attack and in some cases even seems to substitute for the headache. Some patients are greatly depressed and some are very irritable before the attack begins. The headache, as a rule, follows a short time after the premonitory symptoms appear. The pain usually begins in a small spot, more or less constant in location for each patient. It may be on the forehead, the temple or the eyebrow. It is usually confined to one side of the head, but may be frontal or invade both sides. The pain spreads gradually until it reaches the neck when the nausea usually begins. The pain may be severe or mild and the nausea likewise. There is much prostration, in fact few affections are more prostrating. During the attack the patient may not be able to raise the head from the pillow. Noise or light aggravates the condition. The duration of the attack is variable but is usually constant in the individual. The disease recurs for years, but in some cases ceases to trouble so much after fifty years of age. Severe cases may persist throughout life. The usual medical treatment of migraine has been entirely unsatisfactory, except that more or less relief of the acute attack was usually possible. In the past all treatments designed to prevent attacks failed in the majority of cases. In the light of the probable anaphylactic basis of the condition it seems possible that when the treatments did seem to help it was because the case was not true migraine.

In advancing allergy or protein sensitization as a cause of migraine I do not wish to be understood as claiming that all "sick headaches" are allergic. Certainly many cases diagnosed as migraine have been relieved by the oculist's skill. Some have found relief after nasal or other operations; some by attention to the gastro-intestinal tract. In the operative cases and the gastro-intestinal cases it is probable that some were allergic reactions from bacterial or other foreign proteins.

After all these cases are eliminated from consideration there remains much the greater number of cases that are not relieved. These cases are, I believe, mostly if not entirely due to food sensitizations.

In the consideration of cases as possibly anaphylactic, an earnest effort was made to eliminate all but true migraine. Not all headaches accompanied by nausea are migraine. The so-called "bilious headache" is an example. Pituitary headache and the headache at menstrual period, which is probably often a pituitary disturbance, are often mistaken for migraine. These were eliminated.

It is now conceded by medical men that asthma, hay fever and urticaria are due to protein sensitization or allergy. In these diseases we find a definite hereditary tendency, not always to the same disease, but to some one or more of the group. In taking the family history of patients suffering with asthma, hay fever, or urticaria I have found a remarkably frequent history of migraine in some one or more members of the family. Likewise in taking a family history of migraine cases I have found an equally frequent history of some of the well recognized allergic diseases. In each condition a positive family history of allergy can be found in about fifty per cent of the cases.

Migraine, like asthma, is paroxysmal in type. It frequently recurs with great regularity, often coming on the same day of the week. Patients find that much the same factors predispose to an attack, viz. emotion, fatigue, loss of sleep, etc.

French medical authors have led in the claim that migraine is an anaphylactic disturbance. They have reported some success in treatment by giving peptone by mouth for its non-specific effects. In many cases it is successful but

must be given continuously in most cases. When stopped the old condition recurs rather quickly. J. L. Miller and others in this country have reported some success by the hypodermic use of peptone. It frequently fails and practically all patients relapse soon after stopping treatment.

Results of Protein Sensitization Tests

Additional evidence for the anaphylactic basis is furnished by protein sensitization tests and results found by acting on the information gained by that means. I have found that a careful testing of cases almost always gives a reaction to some food substance. At times multiple reactions are had, sometimes single. The reactions are not so well marked as in other allergic disturbances and are frequently different in appearance from the ordinary reaction as generally accepted. This is, I believe, the reason why others who have made these tests have not had success.

Finding substances to which the patient reacts does not, of course, prove that they are the cause of the headache. They may be the cause of some other disturbance of which the patient makes no complaint. However, if we eliminate the foods from the diet entirely and the headaches fails to appear as usual we can begin to suspect that we have found the cause. After a sufficient period of time I advise patients to resume eating the food or foods. Usually this brings on an attack rather quickly. If so, the foods are again eliminated. As a rule the attacks stop again. In case of multiple reactions an attempt is made to find which one is really the cause of the attack.

During the last three years I have had quite a large number of cases which I have tested out more or less completely and have had opportunity to follow up for final results. The results have been so very good that I believe all severe cases should have the tests made to discover the cause if possible. In addition to my own work I have had a verbal report from another specialist in allergic diseases that he has had results comparable to mine.

To illustrate the wide variety of foods causing the trouble I will cite a few typical cases.

Case 1.—W. B., male, age 54.

Family History: Mother had some asthma in later life. One sister had attacks of asthma or migraine, one substituting for the other. One period of several years elapsed without asthma, but with regular migraine attacks, followed by a period of one and a half years of asthma, without migraine. As a rule the attacks are more or less alternated. Another sister had very frequent attacks of migraine.

Patient's earliest recollection was of having headaches often. For the last twenty years attacks were regular and weekly, usually on Sunday, lasting for either twelve or eighteen hours. Frequently attacks came on during the week. Tests showed only a slight reaction to wheat. The complete elimination of wheat resulted in stopping all attacks for a period of seven weeks. A break in the diet at that time caused a mild attack. A resumption of the diet gave four weeks of relief; then another mild attack after eating a small amount of food containing wheat. After a further period of about a month a full diet of wheat was advised with a quickly following headache. A densitization was attempted but never fully carried out. At present the patient reports he only has attacks when he indulges in too much wheat.

Case 2.—A. E., male, age 27.

Family History: Father had asthma.

Patient began to have migraine at about sixteen years of age. At first attacks were only once or twice a year; now more frequently, once a month or so, but irregular in time. Pain was so severe that patient said if he did not get relief he did not care to live. Attacks lasted one to three hours. Tests showed a slight reaction to onions. Elimination of onions from diet seems to have permanently stopped the attacks.

Case 3.—S. M., female, age 18. No family history of allergy. She had headaches for last two years which she believed were caused by milk, cream or butter. Attacks began one to three hours after eating. Formerly she had daily headaches which were relieved by glasses. Sick headaches lasted for a variable time. Tests were all negative except "suspicious" to wheat and positive to tuna fish. Patient was

advised to eliminate tuna fish from diet. She returned in about three months and stated that she had tried eating tuna fish and that each time she promptly had an attack. No attacks had occurred except when she had eaten the fish.

Case 4.—Mrs. P. H., age 51. Family history negative. Attacks began when thirteen years of age and at that time were almost daily. More recently attacks were variable in occurrence but from one to three times a week. Tests showed a sensitization to egg and veal. Elimination of these stopped all attacks for five weeks and then an egg was eaten. An attack promptly followed. She had no further attacks unless eggs are eaten in some form.

Case 5.—Female, age 30. Sister has hay fever. Patient also has fall hay fever. Has had migraine only last few months. Attacks come on one to three times per week and are very severe, with profuse vomiting. Tests showed ragweed as a cause of the hay fever and also a sensitization to olives. Elimination of olives stopped all headaches.

Conclusions

Migraine occurs sufficiently often in the family history of patients suffering from diseases of known allergic origin to make it probable that there is an allergic basis for the condition.

Protein tests in migraine cases shows in a majority a reaction indicating a sensitization to some food substance, the withdrawal of which from the diet stops further attacks.

Medical treatment directed towards prevention of attacks of migraine has so generally failed and the condition interferes so much with the patient's welfare that any means which promises relief should be tried.

Migraine treated as an allergic disease gives results so generally good that physicians are urged to cease saying that nothing can be done and to adopt this method in order that they may bring relief to their patients.

DIPHTHERIA IMMUNIZATION

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Since the discovery of vaccination against smallpox by Jenner it has been the ideal of far-sighted physicians to devise an equally simple and effective protection against the other plagues of mankind. The "Golden Age" of bacteriology in the last quarter of the 19th century, with the rapid discovery of the causative germs of such diseases as anthrax, tetanus, diphtheria, typhoid fever and cholera, gave promise that this dream was about to be realized. Prevention, however, has lagged behind the discovery of cause. In two diseases only have the earlier hopes been even approximately realized—typhoid fever and diphtheria.

The conquest of typhoid fever during the World War by preventive vaccination is too well known to require more than passing mention. Suffice it to say that where in former wars typhoid fever was usually more deadly than bullets, in the past war it was practically unknown among vaccinated troops. In diphtheria immunization the results have been less striking only because the disease is less epidemic in character and the work has been done in civil populations where immunization cannot be required of all members of the community.

Since the general use of antitoxin, about 1900, diphtheria has been a curable disease. Practically all cases that are recognized promptly and given adequate doses of antitoxin recover. A substantial number of children still die of diphtheria on account of failure to recognize the disease in time, and in spite of an available specific cure diphtheria is still the most deadly contagious disease of childhood. In Illinois alone some 4,000 to 5,000 children a year contract diphtheria; of these approximately 500 die and many more suffer lasting injury. The economic loss has been reckoned at half a million dollars per year. During the past winter an especially malignant form of diphtheria has been prevalent and up to the present time nearly twice as many deaths from diphtheria have occurred as occurred during

the corresponding months of last year. Clearly quarantine and antitoxin treatment are not sufficient to control diphtheria; what of protective immunization?

In the city of Auburn, New York, immunization with toxin-antitoxin was begun in 1922. In that year 58 percent of the school population was immunized. In 1923 among this 58% only one case of diphtheria occurred and no deaths. Among the 42% unimmunized 80 cases of diphtheria, resulting in 13 deaths occurred. In 1924 only six cases and no deaths occurred among the unimmunized children and in 1925 only one case and no deaths. Approximately 85 percent of the children of school age are immunized against diphtheria. In New Haven, Connecticut, there has been a decline from 482 cases and 22 deaths in 1921 to 27 cases and three deaths in 1925. In Chicago the death rate from diphtheria has fallen from 24.3 in 1921 to 8.0 in 1925. Syracuse and Rochester have also shown striking decreases in the diphtheria death rate following the use of toxin-antitoxin.

As the name implies, toxin-antitoxin is a mixture of diphtheria antitoxin and the toxin produced by the diphtheria bacillus. Antitoxin gives complete protection against diphtheria for two or three weeks, but after that the patient becomes as susceptible as before. To confer lasting immunity it became necessary to find some process that would more nearly resemble the last protection conferred by an attack of the disease.

In the production of antitoxin horses are injected with increasing doses of diphtheria toxin till their blood builds up a powerful antitoxin to neutralize the toxin. As the toxin alone is very irritating it occurred to Park to mix with it small amounts of antitoxin so that the horses could stand larger doses of toxin. From this beginning the idea occurred: Why not inject people with such a mixture and let them build up a lasting immunity themselves?

As now used the toxin-antitoxin mixture contains just enough antitoxin to not quite neutralize the toxin. In this proportion the mixture is harmless, but stimulates the body to produce its own antitoxin. Antitoxin is manufactured only in laboratories licensed by the U. S. Treasury on recommendation of the Public Health Service. The strength

of both toxin and antitoxin is tested on guinea pigs and the mixture is carefully tested for strength and sterility by the Hygienic Laboratory before it is released for use.

Given in three injections, a week apart, toxin-antitoxin will prevent diphtheria in the great majority of susceptible children. The small percentage of children not protected by the first series of injections almost always acquire immunity in a second series of injections of toxin-antitoxin. Since it requires three to six months for full protection to be established, all children treated should be given the Schick test five or six months after the immunizing injections. Any children found susceptible should then be given a second course of toxin-antitoxin.

The question of requiring a Schick test to determine susceptibility before giving toxin-antitoxin is a matter to be decided largely by local conditions. Natural immunity to diphtheria depends chiefly on two things: age and density of poulation. Children under five, whether in the city or country, are generally susceptible. Up to that age it is not worth while to do a Schick test before giving toxin-antitoxin. In deciding this matter Park says: "The decision simply depends on whether, in any given age group or locality, it is more trouble and annoyance to make the Schick test and so omit unnecessary inoculations, or to omit the Schick test and inoculate all children." In Chicago, where all immunization is done in the kindergarten and first grade or in pre-school clinics, the prior Schick test is not required. In either case a Schick test should be made five or six months after inoculation to see if protection has been secured.

The best time to give toxin-antitoxin is from one to two years of age. At that age children are most susceptible to diphtheria and the disease is most fatal. Since over one-half the deaths from diphtheria occur under five years of age, immunization of school children alone is not sufficient to control the disease. If toxin-antitoxin is to be given in schools it should be given chiefly in the younger grades. If the entering class each year is inoculated on admission, an immune school population will soon result.

It is too soon to say exactly how long protection from toxin-antitoxin will last. In a series of immunized children

in New York City, 90 per cent were still immune at the end of nine years. In most cases it seems probable that protection lasts for life. Even if the immunity lasts only eight or ten years, children immunized early are protected during the most susceptible period of life.

Probably the greatest obstacle to the general adoption of toxin-antitoxin immunization has been the fear of serious reactions. Two or three accidents in the early days of immunization have led to a groundless fear of the whole procedure, and blinded the eyes of many parents to the deaths from diphtheria constantly occurring. Under the present methods of supervision the occurrence of serious accidents is practically impossible. With the present dosage reactions are limited to local soreness in a small proportion of subjects, which may last two or three days, and a still smaller proportion of cases which show slight fever or headache. In over 1,000,000 injections of toxin-antitoxin in New York State, no permanent harm to any child has ever resulted. In Chicago no serious reactions have resulted from some 300,000 injections.

To summarize: we have in toxin-antitoxin an immunizing agent against diphtheria which is inexpensive, safe and simple to administer, which confers immunity in practically all cases, and which gives protection lasting through the dangerous period of childhood.

With such a protective agent available to everyone, what explanation can be offered for the continued, needless sacrifice of children to diphtheria? Simply the ignorance and indifference which still tolerates smallpox 130 years after the discovery of an equally simple and effective method of prevention. The success of any method of disease prevention depends no less on the undertanding and cooperation of the population than on the perfection of the process. The time has now come when any city can determine its own death rate from diphtheria. There is no question that the general use of toxin-antitoxin immunization in all communities would be the means of saving the lives of several thousand children each year, to say nothing of preventing tens of thousands of cases of diphtheria. The great task at the present time is to carry this message to

the parents of all young children. Indifference must be overcome, skepticism and fear dispelled by accurate information until all classes unite in demanding the elimination of this greatest scourge of childhood.

METHODS OF PRECISION IN MODERN MEDICINE.

W. HENRY WILSON, B. S., M. D., F. A. C. P.

In discussing the subject of miracles, John Ruskin stated to a group of scientists, philosophers, and clergymen in a London Meeting that he always expected miracles to happen. Like John Ruskin, the great masses of the people are still unconvinced of the reign of law. They believe that many things just happen and that much may be attributed to luck. This is particularly so when it concerns diseases, their recognition and management. The thesis, therefore, that I wish to defend is:

First—During the past few years the methods of physics, chemistry, and biology have been applied to the solution of medical problems with the result that medicine is approaching more and more to an exact science and consequently a successful art. As a corollary to this proposition, I believe that it follows logically that since these methods of exactness require the use of special instruments and special technique, their application requires the cooperative work of several trained men. It is no longer possible for any one man to master and use all of these procedures. It follows, therefore, as second conclusion, that medicine is no longer a one man art. No man can practice this art alone. Third conclusion and one of equal importance is that after all of the scientific methods have been applied in the evaluation of the patient or in the evaluation of his several organs, there still remains the problem which is the most important of all, and that is the bringing together of all accumulated data, assign to each its proper value, give it a final interpretation and above all, determine what should be done. This is the work of the internist.

It was Josh Billings, many years ago, who made the assertion that it is not ignorance that afflicts us, it is knowing so much that is not so. This is true in all branches of thought.

Self criticism is one of the first signs of progress in any branch of thought.

In our most advanced medical groups, self criticism has become very apparent, with the result that every department of medicine is being re-examined and re-valued.

At the present moment there is scarcely a large educational institution in America, that is not making a resurvey of our knowledge of the organs of the body and their functioning, with the purpose not only of determining what their duties are, but also to establish means and methods of estimating these functions. Modern medicine is not so much concerning itself with the administration of drugs as it is to find out exactly how the several organs function, what they contribute to life and defense, and what the causes are that disturb this functioning and how to remove the cause.

Medicine like religion and politics, has it's fundamentalists and modernists. The fundamentalists are those trained under older methods, who have reached their maturity, and who have developed a great personal capacity for meeting the problems which confront them daily. They view with scorn the introduction of newer instruments, such as the electro-cardiograph for measuring the functioning of the heart, the various laboratory methods that assist in the diagnosis of acute and chronic diseases. They assert with much confidence that these new fangled procedures stunt the physician's mental growth and prevent his developing that individual clinical ability which is so much needed in medicine.

The modernists, however, continue diligently in the developing of new methods and new procedures which enable them to do earlier in life and with much greater accuracy what the old fundamentalists could do only after years of experience.

These modern methods of precision have lead to results which are nothing less than startling in their accomplishments. That modernism is justified, I wish to prove to you by pointing out:

First—What it does for accuracy in diagnosis, and

Secondly—What it has achieved in the matter of treatment.

Under the first title, I shall select a single organ or pair of organs with which you are all familiar, namely the

integrity and capacity of the kidneys. This problem may be approached in five different ways. In other words, we have available five entirely different methods of testing which may be applied. The first of these is the examination of the eye grounds or retina. It is not infrequent that the first signal of a kidney damaged, is recognized by the competent oculist.

The second method of approach is one of the oldest in medicine, namely, examination of the kidney excretion. This is so well known that it need not be elaborated. A third method of approach is the determination of kidney functioning, and since the kidneys perform a number of functions, we have a group of tests rather than a single test. For example, we may test by means of a high protein diet, the capacity to excrete urea, and other nitrogenous substances. By another diet, we may determine the capacity to concentrate the urine, by still another, the capacity to eliminate water. And finally, by use of a dye, the general functioning capacity of the kidneys. This latter is known as the phenolsulphonephthalein test and has a particular value to the surgeon.

A fourth procedure is the use of the cystoscope. By the use of it, we are able to determine the kind of material which is being delivered. By cystoscoping each kidney separately, we are enabled to secure secretions of each kidney separately, and we are further enabled to determine the functional capacity of each kidney separately.

The fifth method is determining the renal anatomy and renal physiology by use of the x-ray. This enables us to determine, the presence of renal stones, frequently renal tumors, the size of the kidneys, presence of cysts, and sometimes the presence or absence of pus or other fluids in the renal pelvis.

Sixth we have a court from whose decision there is no appeal, it is the chemistry of the blood stream. The witnesses are the several substances which are normally present there in small amounts. It is the kidneys' duty to evict all above a certain number of milligrams. No guessing is needed, these substances are determined and the kidneys acquitted or proved guilty of incompetence. With the exception of the examination of urine, all of these have been

developed in recent years, and by their combined use, we are enabled to survey and estimate the structure and function of the kidneys with an accuracy that certainly closely approaches that of the other modern sciences in solving other problems. What we are doing for kidneys we are beginning to do for other organs.

Can modernists show an equally gratifying progress in the treatment as compared with the recognition of disease? I believe it can and I shall mention but two triumphs to confirm the statement.

First—The use of the hormone, Insulin in the treatment of diabetes is not surpassed in its far reaching results by any other single modern discovery. It is not a medicine. It is supplying to the patient with diabetes, a ferment, a hormone, a necessary substance which his own organ cannot produce. What is the result? An almost immediate relief from distress, a return to health, a capacity to perform his regular duties, and above all, instead of confronting an early death, he now has prospects of living to the fourth, fifth, or sixth decade. Instead of being a burden to himself, a victim to every mild infection that comes his way, an impossible surgical risk, he can face the world like a man, and live in the hope of seeing many years of happiness. In other words, the use of Insulin coupled with diet which has also been developed by modern science, has added millions of years to lives of human beings.

A second triumph of modern biological chemistry has a somewhat narrower field, but is no less dramatic. There come to every large contagious hospital, victims of diphtheria, who have been neglected by virtue of ignorance, indifference, or poverty. They are usually received in a dying condition. Either they are found bleeding from the mouth or nose, or their necks are girdled with lumps. In either case, death is an equal certainty. During the past year, at the City Hospital at Cleveland, the blood chemistry of these patients, was studied with great care. It led to the discovery in all of the victims that the blood sugar was extremely deficient, amounting sometimes to one-fifth of normal. Since the blood sugar is a necessary food for muscle tissue and especially for heart muscle tissue, the

conclusion was reached that it might be of service to these hopeless victims to administer a solution of sugar intravenously. This was immediately tried with the result that out of 80 cases, 44 were saved.

I know of nothing more dramatic or more inspiring in all history, and yet the adoption of a litter of skunks by a mother cat received one thousand times more publicity.

By the free use of the methods of precision developed in chemistry, physics and biology, medicine is becoming a precise art with a mathematical foundation. Personal equations are diminished and the recent student stands, as it were, on the shoulders of the fathers.

These methods of precision require special trained physicians (not merely technicians) in each fundamental branch. Consequently medicine is no longer a one man job but requires the cooperation of several. This is particularly true of personal health surveys, health surveys which require the recognition of disease in the very incipiency. The one man health survey is of small value.

The greatest advances made in treatment have come through applied biochemestry as noted above.

Since diagnosis and treatment can no longer be carried out by one man alone the medicine of the future must be more and more an institutional function.

PAPERS IN PSYCHOLOGY AND EDUCATION SECTION, JOLIET.

A STUDY IN THE PREDICTION OF SCHOLARSHIP.

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Many lines of investigation in the problem of predicting college scholarship have been followed. The possibilities of estimating at the time of entrance a student's academic success in college, on the basis of physical and sensory traits, of high school grades, of entrance examinations, and of intelligence test scores have all been tried. Predictions based upon physical and sensory traits alone have proved of slight value, and those depending upon high school grades, entrance examinations, or intelligence test scores possess a large element of error. College scholarship undoubtedly is the resultant of many forces and influences, and any single factor will scarcely serve as a basis for an accurate prediction. There is the possibility, however, that a combination of measures, none of which shows a particularly high relationship with scholarship, might enable us to predict scholarship with greatly increased accuracy. The technique for making such a combination is the method of multiple correlation. It may be stated at this point that the chances for a high multiple correlation coefficient are best when each of the measures entering into the combination exhibits a fairly high correlation with the criterion, in this case college scholarship, and a low correlation with one another. Our problem, then, is to determine the factors which influence scholarship, and to make the best combination of these factors for its prediction.

The present study was made to determine the accuracy of predictions of college scholarship made on the basis of the best combination of measures which were available in the case of students of Ohio State University. It was recognized that there are other factors influencing scholarship which were not found among those available for this study. Measures in fourteen factors were secured for each of 416 students selected at random from the class of 1925 of the College of Arts of Ohio State University.

Six of these measures were in physical traits and the zero order correlation coefficient of each of these traits with college scholarship was as follows: weight, minus .12; chest expansion, minus .02; lung capacity, plus .02; height, plus .07; pulse, plus .13; vital index, plus .13. None of these coefficients indicated a close relationship with scholarship, but it was possible that measures in one or two of these traits when combined with measures in other traits might serve to increase the accuracy of the prediction appreciably. The other traits correlated with scholarship and the coefficients of correlation were as follows: age, minus .07; number of units of high school work, plus .21; the total of all high school grades, irrespective of whether the number of units was the same for all students, plus .44; average high school foreign language grade, plus .50; intelligence test score, plus .51; average high school English grade, plus .53; average high school mathematics and science grade, plus .54; average high school grade, which included all subjects, plus .57.

While several of the above correlation coefficients may be regarded as fairly high, it is quite apparent that predictions of scholarship based upon coefficients of such magnitude will in many cases prove to be considerably in error. The next step was, therefore, to determine whether these measures, when combined and weighted in the best possible manner, would permit more accurate predictions of scholarship. The multiple correlation and the multiple ratio correlation techniques, explanations of which may be found elsewhere,[1] were used in answering this question. It was noted just above that the zero order correlation coefficient between college scholarship and the average high school grade was plus .57. Beginning with this measure, which correlated highest with scholarship, which of the remaining measures when combined with this first one will yield the highest multiple correlation coefficient? The measure found to do this was the intelligence test score, the multiple correlation coefficient between scholarship and the best weight-

[1](a) Yule, G. U. An Introduction to the Theory of Statistics, p. 248. London, Charles Griffin and Company, 1922.

(b) Clem, O. M. Detailed Factors in Latin Prognosis, p. 27-28. New York, Teachers College, Columbia University Contributions to Education, No. 144, 1924.

(c) Garfield, Evelyn. The Measurement of Motor Ability, p. 18-20. New York, Archives of Psychology, No. 62, 1923.

ed combination of the average high school grade plus the intelligence test score being plus .648. After these two measures were used in combination as a basis for predict ing scholarship, to what extent did the addition of a third measure to the combination serve to raise the correlation coefficient? Of the twelve remaining measures, the one which made the greatest contribution to the two already being used was the vital index. The correlation between scholarship and the best weighted combination of the average high school grade, the intelligence test score, and the vital index was plus .654. Furthermore, the addition of all the remaining measures to the combination served to raise the correlation only to plus .665. That is to say, when a prediction of college scholarship is based upon the average high school grade and the intelligence test score, its accuracy is not appreciably increased even though all of the other twelve variables included in this study are taken into consideration.

It was also desirable to ascertain the relationship between these various measures and college scholarship when all the other factors were held constant. This was done by means of partial correlation. The results indicated that the closest relationship of college scholarship was with the average high school grade and the intelligence test score when the older factors included in the study were held constant. The correlation coefficient between college scholarship and the average high school grade, where the zero order correlation was plus .57, became plus .47 when the influence of all the other factors had been eliminated. In the case of college scholarship and the intelligence test score, where the zero order correlation coefficient had been plus .51, the correlation when the other influences had been ruled out by partial correlation was plus .38. Of the remaining factors, the highest partial correlation with scholarship was found in the case of the vital index, the coefficient being plus .12. It is thus apparent that both the average high school grade and the intelligence test score are unique in their relationship with scholarship. Only these two factors each showed a fairly high correlation with college scholarship when the concomitant influence of all the other variables was eliminated. Each of these two

measures supplied a factor for the prediction of college scholarship which could not be gained from any of the other variables included in this study. Furthermore, as might be inferred from what has just been said, the data revealed that the presence or absence of either of these two measures significantly affected the accuracy of the estimation of scholarship.

The next step was the writing of the regression equation by means of which the college scholarship was predicted on the basis of the best combination of the average high school grade and the intelligence test score. This equation was as follows: $X_1=3.58\ X_2+.46\ X_3-268.2$. In this equation X_1 is the scholarship score which is to be estimated on the basis of X_2, the average high school grade, and X_3, the intelligence test score. It may be stated here that the scholarship score was the average number of honor points earned per year when each quarter hour of A grade work counted four such points; B, three points; C, two points; D, one point; and E, no points.

Several illustrations will serve to make clear the use of the regression equation in making the estimates or predictions of scholarship. Student A entered Ohio State University as a freshman at the same time as did the group included in this study, but he was not one of this original group. A's average high school grade was 75.5; while the mean of the average high school grades for the group included in the study was 85.4, and the standard deviation 5.2. A's intelligence test score was 92; the mean of these scores for the group was 109.6, and the standard deviation 30.1. Using the regression equation, it was found that A's predicted average number of honor points per year was 45.2. Since a student at Ohio State University carries ordinarily about sixteen hours of work each of the three quarters of the year, this means that a prediction of an average grade of approximately D would be made for this student. A's actual achievement in scholarship turned out to be 55.5 points, which was very close to the predicted score.

In the practical situation of predicting scholarship, however, the scores which would subsequently be made

would still be in the unknown future at the time of prediction. It would therefore be important to have some notion at that time as to how accurate the prediction will prove to be. This information is given by the standard error of estimate or the probable error of estimate. The probable error of estimate, when the prediction was based on the average high school grade and the intelligence test score, was found to be 21.7 points. This means that the chances are even that the actual score will be within 21.7 points of the estimated score. When estimates of scholarship were made for thirty additional students by means of the regression equation which was derived in this study, and these estimates were checked with actual achievement scores in scholarship, it was found that in seventeen of the thirty cases the error was less than the probable error of estimate.

In predicting college scholarship, how serious is an error which is equal, for example, to this probable error of estimate? Suppose that an entering freshman student has an estimated scholarship score of 96 points. Assuming that he carries sixteen hours of work each quarter, this means that his predicted average grade is C. The chances are even that he will actually earn not less than 74.3 points, nor more than 117.7 points; or to state it somewhat differently, the chances are even that his grade will not be lower than a combination of grades C and D, in which the C's predominate (for example, 27 hours of C and 21 hours of D), nor higher than a combination of grades C and B in which the C's again predominate (for example, 27 hours of C and 21 hours of B).

Another illustration may be presented which involves the regulation of Ohio State University that students failing to make an average of 1.8 scholarship points for each hour of work carried (an average slightly below C) during the first three years are to be dropped from the university at the end of the third year. Assuming a schedule of sixteen hours of work, this means that a student must make a total of 86.4 scholarship points per year. Suppose that the estimated scholarship score for a given student who will carry sixteen hours of work is 65 points. It will be noted that this is almost exactly one P. E. distance, 21.7

points, below the minimum required. What is the probability that this sudent will meet the minimum requirement, in spite of an estimated score of only 65 points? The chances are even, it has been stated, that his actual score will vary 21.7 points or more from the estimated score. However, there is as much probability that this variation will be in the direction of a lower score as in the direction of a higher score. Consequently, he has one chance in four of meeting this minimum requirement; or, of four students for each of whom a score of 65 points is estimated, one only may be expected to make a score as high as 86.4 points.

Another student who has a percentile intelligence rating of five, or an original score of 60, and a high school record better than that of sixteen percent of entering freshmen at Ohio State University, presents himself for admission. That is, his average high school grade, which is 80.2, is one standard deviation below the mean. Accordingly, his predicted scholarship score is 47.1 points. This is 39.3 points, or 1.81 times the probable error of estimate, below the minimum required of a student with a schedule of sixteen hours. He has but eleven chances out of one hundred of meeting the standard of 1.8 honor points for each hour of work carried.

The data which have been presented do not of course answer the question as to whether such a minimum requirement of an average of 1.8 honor points per hour of work, or some similar regulation, is or is not a desirable requirement. Neither do they answer the question as to whether, if it were possible to determine at the time of application for admission those students who will, to a high degree of probability, fail to meet such a requirement, such students should be denied admission. The data do, however, permit an estimate of college scholarship which may be accompanied by a statement of the probability that the actual accomplishment of the student will vary from this estimate by any given amount.

It seems evident from the data presented that admission to college should not be based alone upon an intelligence test rating. Even where the purpose of the college or university is to admit only those students who will achieve a certain degree of success in scholarship, this

object can be attained more satisfactorily if other criteria in addition to the intelligence test score are used. Certainly, to such a score some measure of high school scholarship should be added. The present study has shown that either of these two measures taken singly does not result in as accurate a prediction as the inclusion of both will give. On the other hand, if to the combination of these two factors any or all of the remaining measures included in this study are added, the accuracy of the prediction is increased scarcely at all.

SOCIAL WORK AND HUMAN REMAKING.

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Consider for a few moments such varied types of human beings as the Shelton Brothers, Leopold and Loeb, Thomas Edison, Babe Ruth, Henry Ford, Jane Addams. These are but samples that express the variety which is endless. We might go on and show hundreds of types of personality. Why is there so much difference between human beings? Is there anything that can be done about it? We take it for granted that certain types of personality, such as were represented by the Shelton Brothers, Leopold and Loeb, are not socially desirable, and that the world would be better off if in future generations these types can be eliminated.

What is this thing personality that differs so in various individuals? Does it change? If it does, can these changes be made to take a certain direction?

There are those in this country who say that heredity is the cause of all these differences, others that environment accounts for everything. The evidence of modern psychology and sociology and the evidence of our own common sense points to the fact that personality as it is in any individual at any particular time is the result of a combination of the hereditary forces and the environmental forces. What any individual is today is due to the moulding force environment on the physical entity of the body, the mind—all that was inherited. Heredity gave us the potentiality, the crude clay upon which the forces of environment have worked and moulded the combination that we find at the present time.

Personality is an all-inclusive term that describes any individual. It includes everything that he is—his physical being, his ideals, his habits. It is better in understanding personality to make "habit" include not only those things that we ordinarily speak or as habits, but to include all actions that have been learned and represent the response of that individual to different kinds of situations. We have our work habits that include many minor habits that are very complicated, and differ according to the kind of work that

each of us may be engaged in. We have our father habits, our mother habits, our church habits, our citizenship habits, recreational habits, sleeping habits. Pervading all of these what may be called our thought habits, for our so-called mental activities are as subject to certain ways of doing things that we have learned as any habits. Of great importance are emotional habits. The term habits as we shall use it then in conjunction with personality describes the sum total of man's responses to his environment at any particular time, and are the means of measuring the personality, of describing the kind of man.

It is easy to observe that from the period of birth throughout life habits are developing in response to outside forces, a response of the hereditary tendencies of forces with which we were born. Since no two individuals are born with exactly the same hereditary forces and since no two individuals have exactly the same environmental forces acting on them, we see the reason why none of us are alike, and why we have the differences in personality indicated by the few names that were presented at the beginning of this talk.

Further, we see that with this view personality is a continually changing thing in any individual. We have only to look back into our own lives a few years to see the changes that have been made. These changes are evidenced by new habits that we have developed, old habits that we have dropped. Usually the changes are gradual and slow, but like the weather, they may be sudden and catastrophic. We have all of us seen a person that has been so changed in a short time that we wonder. Whether the change is slow or rapid, it may be a change for what we call the better or the worse—meaning by better that the change has been in a direction that we approve, and for the worse in a direction that we disapprove.

What kind of forces are those that are particularly significant in shaping personality? First are the bodily changes due to growth and the reaching of maturity; particularly striking are those attendant upon the sexual development of the early teens. The bodily changes are not subject to much control. How we shall grow depends chiefly on our heredity and the nature of this is evidenced by the responses we make to certain kinds of environment. Second,

and of particular interest to us, are the environmental or external forces that bring about changes in personality. In childhood these are primarily the home, parents, brothers, and sisters, the neighborhood, playmates, and later on the school, the church, the playground. With age the circle of environment gradually widens until it includes all of the complicated stimuli that affect the adult. During the adolescent period comes the powerful play of ideals in shaping personality. Ideals are an external force depending on the personalities of other persons with whom one comes in contact, not only in the neighborhood, but in the community, the nation, and to a considerable extent, the whole world, as evidenced by the recent world war. Love, courtship, marriage, birth of children, rearing of children, sickness, death are among the most powerful of the environmental forces.

Would there were time to trace in some detail the kind of things that happen to personality from year to year, or to take some individual and follow up his personality changes from childhood to maturity.

The significant thing is that all through life the human being is subject to the interaction of the internal forces that represent heredity and growth, and the external forces. To illustrate simply, there are not only sounds all about us, but our sense of hearing is reaching out at all times to capture those sounds; there is not only work to be done, but our hands and bodies are eager and reaching forth to perform the things that are waiting to be done. There are not only community points of view, ideals, and customs, but we have natures that are reaching out to accept these and make them part of ourselves.

As was indicated, the internal forces are not subject to control except through outside forces that play on them. We can hear only the sound waves that reach our ears; we can see only the things that are within the range of our eyes, we can do only what we have learned to do with our hands or our bodies, and our thinking, our ideals follow the patterns that have been set for us by outside forces.

The trouble with the external forces is that they are not designed to meet individual pecularities, individual needs whether of strength or weakness. The human beings living in the latter part of the eighteenth century never intended that Napoleon's skill in manipulating human be-

ings and managing wars should result in such wide-spread suffering, such national changes, such an upset of Europe as occurred.

Man has learned, however, that he can change and control some of the external forces and bring about thereby conditions that improve the human being, in other words, a personality change in an approvable manner. Take for example conditions of employment, methods of education, public recreation. These are environmental forces that are applied to groups and by group methods, and thereby affect the individual. Many other forces are, however, as yet seemingly beyond our control, particularly the customs and ideals, which are continually changing but not according to human plan. There are, for example, many persons who would prevent war, but they do not have the power to do so. It is also evident that in addition to influences on groups by social changes, one may deal with individuals in certain parts of his environment to bring about valuable personality changes in the individual. This is usually done by one individual for another, the parent for the child, the clergyman for those who come to him for help, the doctor for his patient. These efforts to change personality are usually limited in their intents and effect. The doctor is concerned with building up health rather than changing the personality in a certain way. The changes may occur indirectly. The parent who has a wayward boy is usually unable to handle that situation unaided. He may, however, by sending the boy into a new environment, such as a particularly good school, bring about a development of new habits that break up the ones that were classed as wayward. The clergyman approaches from his point of view the problem of the individual, dealing particularly with the religious life, although very frequently he goes much further.

Some months ago a former criminal, known as Black Jack, wrote a biography entitled "You Can't Win." It is an excellent demonstration of how personality is swayed for the worse by environment, and how finally the efforts of one man who interposed personal kindness and new environmental opportunities, broke up all of his habits of law breaking, and made him a law abiding citizen. Although this reformer was not a social worker by profession, he used the methods of social case work.

We have noted a number of the chief environmental forces that create personalities. We have pointed out that their action does not take into account individual differences. Unfortunately, some of the same external forces will produce different personalities in different persons, and because of their failure to take into account differences in individual adjustability we have created a large class of dependent, inefficient persons, parasites, law breakers, those who are chronically sick mentally and physically, and those who have bad habits that sometimes produce serious effects, such as reckless drivers, drinkers of bootleg liquor. We have noted that some of these external forces can be controlled and made better adjusted to the needs of individuals, that by social action changes have been made in the industrial, educational, public health and hygiene, and other fields which have reduced the number of individuals that have suffered from them.

Social work is the organized effort of society to adjust environmental forces in order to improve personalities. Part of this is done through group effort. In this program approved ideals, interesting educational programs, recreational and other projects are given to groups. Examples of this type of social work are found in the Y. M. C. A., Y. W. C. A., Boy Scouts, Girl Scouts, City Recreation programs. Not all of the individuals who are brought under the influence of these efforts are benefited thereby, because there is a lack of individualization. It does not fill the need of everyone, and considering the diversity of personality, it can readily be understood that no set program or group work can reach everyone.

There is another type of social work which deals with the individual as a specific problem. Here the personality of the individual is studied in relation to the environmental forces that are acting on him and have acted on him, and the attempt is made to change his external forces, to build up new ways of living which include the development of new habits and throwing off of old habits that are bad.

This is known as social case work, and is the method followed by family welfare organizations, children's welfare and aid societies, juvenile courts, mental hygiene workers, and others who deal with individuals rather than groups.

For example, a mother with two daughters was found living in a hovel, filthy, badly furnished. The mother was drinking heavily and was using her children to beg and steal in order that she might get the means of providing herself with a sufficient quantity of liquor. The social case worker made a diagnosis. There were two forces in the life of this woman which offered promise. These were her fondness for her children and the fact that she had some relatives who were well adjusted to life. The children were immediately taken away and placed in an institution. The mother was also placed in an institution where she could be removed from the temptation of liquor and given training in housekeeping and work. She was put on probation in order that she might put herself in a position where her children might be returned to her, and a home of their own established. It took six or seven years of effort on the part of the case worker to achieve this result. She did it by a skillful control of the environmental forces playing on that woman and her two children. The family is now living in a neat little home that they are purchasing, the younger daughter doing well in school, the older daughter working and about to marry a substantial young man, and the mother living a satisfactory life in friendly relation with her neighbors, relatives, and her church.

We cannot take time to describe the elements of case work in detail. It is still in its infancy, but it is a rapidly developing child, not only in the amount of work it is doing, but more significantly in the technique and science that are the basis of its action. It must find out much more about the relationship of the forces that go to make up personality. It must find out much more about the control of forces that are developing bad personalities and good personalities and how to overcome them. Since social case work must use, to accomplish its results, the achievements of the medical profession, of education, of industry, of religion, of psychology, or sociology, its advance is dependent on the advance of the sciences underlying those activities, and the opportunities they afford for application to individual instances.

Case work is the most complicated of human efforts since its attempts to take into account personality and environment in which it lives, and the possibilities of other

environments. In the not too distant future it should be possible for any individual who is in trouble to go to a professional case worker and have his personality straightened up as it is now for a person having appendicitis to have that taken care of by a surgeon, and just as the science of medicine has made it possible to reduce the number of persons suffering from typhoid fever, so it should be possible for case work to furnish information which would enable society to largely reduce the number of persons who are dependent, who are law breakers, who are inefficient.

It is fortunate that the American public has shown so much interest and given so much encouragement to the development of the profession of social case work. The returns up to the present time are not great, but the effort is well worth while, because of the possibilities that lie within it, even though these are possibilities that will not be realized by this generation or the next. It will possibly never be the means of remaking the human race, but it does offer the possibility of remaking many of the individuals who under the present condition of living are unable to make their own lives satisfactory to themselves or their friends or the community in which they live.

PAPERS IN HIGH SCHOOL SCIENCE SECTION, JOLIET.

A RITUAL AND OTHER DEVICES FOR HIGH SCHOOL SCIENCE CLUBS.

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Because the universe—its mysteries, its allurements, its beckonings—will never let us alone. —Albert Wiggam.

From time to time the question of the relative scarcity of high school science clubs affiliated with the State Academy has presented itself to me. Recent communications from the chairman and the state secretary have served to indicate the possibilities of the ritual and other devices with reference to this particular problem. The matter of creating an appeal to those whose best interests such affiliation would serve—that is, to the high school science instructors and students—must begin with a demonstration of practical values.

Possibly the devices I am about to discuss are being used in other science clubs. In any event, it is not intended that they be considered either new or original. If, however, the applications of the ideas, as suggested, serve in any way toward a more numerous group of affiliated science clubs, I shall feel content. The specific devices which I shall consider are standardized club pins, standardized cards of membership credentials for individuals, and a standardized ritual to include illustrative material. These three devices, in some form, have been employed in the two clubs with which I have been identified. The results, it may be said, were sufficiently satisfactory to warrant their use again, should nothing more appropriate be available.

The first club to which I have just alluded was organized in a more or less isolated community some six years ago. Certain incidents preceding its origin indicated the need of considerate action on the part of any one who attempted to present scientific conceptions to the students there. The idea of the ritual as it was developed, then, may be accounted for in terms of the rule of causation proclaimed by the ancient Leucippus, "Nothing happens without a cause, but everything with a cause and by necessity."

My primary objective at that time was to illuminate a peaceful path between science and religion. It may also be noted, however, that through such a plan it is easy to establish something of the ethics of science and something of its humanism as well as its material benefits, thereby approximating to a more accurate degree the totality of the needs of those who think to travel by its light.

The objectives of citizenship and life interests as concrete examples are easily encompassed by the ritual. The significance of citizenship is being appreciated more and more by educators. Elementary science text books are being built around that essential of human welfare and progress. Such texts may serve well for the time allotted to work, but what of play? Not every boy has the opportunity of being a scout; not every girl has the privilege of being a member of a camp fire organization. Even if they could be, there is still no assurance that they would find in such activities exactly what each needed in this respect. Spencer points to this when he says that to educate rightly is not a simple and easy thing, but the hardest task which devolves upon adult life. Through the ritual and in the presence of the symbols of citizenship accompanied by appropriate interpretations of them, the student may become better acquainted with an adequate appreciation for the traditions and institutions of our democracy. He may also satisfy certain life interests and values for which he is as yet ineligible without indulging in objectionable secrecy. High school students of today have some idea of formal and informal initiations that enter into collegiate fraternities and other (adult) fraternal orders. Sociology indicates that a desire for such activities is more or less instinctive. Furthermore, the use of the ritual in science club work may, through the psychological principle of substitution, help to prevent any tendencies toward the establishment or growth of illegal high school organizations that exist by virtue of carefully planned and executed alibis. The conceptions of good citizenship and life-interests as correlated with the spirit of science have appreciable possibilities.

A standardized ritual worthy of use in clubs affiliated with the Academy would require some effort to prepare. Once completed, however, it should be of real value, partic-

ularly if supplemented by carefully edited illustrative material in the form of a series of opaque pictures for use in suitable projectors, films, slides, and the more convenient film-slides. In these three forms almost every possible demand for "picturization" could be met. In the second club with which I have been identified, opaque pictures were used and supplemented by films bearing on the life of Edison whose name was selected to designate the organization. If care is taken in selecting names for the local organizations, much supplementary material in the form of films that will add a further note of interest to the work may be obtained. In many instances such films may be had from industrial and other sources for express charges. Lists of these films with synopses and sources would be advantageous. The series of opaque pictures, the slides, and film-slides should—under specified conditions—be available for loan from the Academy to the affiliated clubs for use in the initiation ceremonies.

A standardized card for membership credentials for each individual should bear a statement of affiliation and also the signatures of the state officers as well as provisions for a counter signature. The ritual and the card, together with the standardized pin, linking individuals and clubs alike, would—it is believed—serve as a further incentive toward increasing the number of clubs. Certainly the dignity of these measures is at once apparent, and the pride necessary to the growth of any institution is apparent as a natural and unescapable consequence.

To reach the instructors, who must in the end sponsor the clubs, may be rather a difficult problem. Science teachers, as a rule, are busy with such a multitude of details that only those who have attempted the work of organizing and conducting simultaneously several courses in science can appreciate the view taken toward the added responsibilities. Yet science teachers, I think, are as quick to recognize values as any other group. If they could have the assurance that distinctive materials for the development of a science club were easily available, this fact would constitute a forceful argument for the furtherance of affiliations. In addition to the use of mailing lists and of space in the scientific magazines, a simple and direct method of ap-

proach would be to enlist the aid of those in charge of science teachers' training courses in the several schools throughout the state. A portion of one class hour devoted to the cause of extending the benefits of science beyond the class room is neither too great a thing to ask, nor yet too much to give.

Wiggam has said, "The things science has discovered are as nothing compared with the spirit and kind of life it has brought into the world. The spirit of science is worth vastly more than the discoveries of science." The standardized card of membership credentials, the standardized pin, and the ritual with edited illustrative material, all represent details among the many possible ways of contributing to the significance of that spirit so necessary as a guide in the discovery of our future.

I am glad of the opportunity of addressing this section of the Academy, because I feel that the Academy represents a means whereby the spirit of science may find its way into the consciousness of the commonwealth it is now serving fully in other ways.

Bibliography.

1. "Transactions of the Illinois State Academy of Science," Volumes XVII, XVIII, and XIX.
   Three clubs (Galesburg, Danville, and Eureka) have maintained a membership continuously since 1923, one (Englewood) since 1924, and one (Henry) since 1926.
2. Gomprez, Professor Theodor, "Greek Thinkers," p. 21, John Murray, London.
3. Wiggam, Albert Edward, "The Religion of the Scientist," World's Work, Vol. 50, No. 4, August 1925.
4. McMurry, Doctor Charles A., "My Philosophy of Education," The Phi Delta Kappan, Vol. IX, No. 5, April 1927.
5. Gregory, R. A., "Discovery, the Spirit and Service of Science," Macmillan. Obtained as one of a set of five books from The Chemical Foundation, Inc., 85 Beaver Street, New York, for the cost of printing: $2.50 the set.
   This reference contains many appropriate pictures, among other things.
6. "School Law of Illinois," Circular No. 202, Fraternity,
   An act to prohibit fraternities, sororities in the public schools of the State, and to provide for the enforcement of the same. Approved June 28, 1919.

INITIATION CEREMONY OF THE (EDISONIAN SCIENCE) CLUB.

LOUIS A. ASTELL, WEST CHICAGO, ILLINOIS.

The initiation ceremony takes place after the regular business meeting, when only members of the club are present. Once in four years the ceremony might well be given before the assembly. It should, of course, follow the annual campaign for membership. The symbol (M) refers to music and (S) to appropriate slides, film-slides, or films.

President. We shall now proceed to the initiation. You are requested to remain in silence until the ceremony is concluded. The vice-president will ascertain if there are any eligible students (or teachers) of this school seeking admission to the (Edisonian Science) Club.

(The vice-president salutes the flag—placed at the right of the president's desk—and at such an angle that the president, vice-president, and flag are in line—then proceeds to the adjoining room. Returning, he stands within the doorway and addresses the president.)

Vice-President. Sir, I find the following who are qualified for membership in the (Edisonian Science) Club and who seek initiation therein.

President. You will conduct them into the meeting hall and place them properly before the flag.

(The vice-president retires to the adjoining room, leads the candidates in file, to the tune of National Emblem or other appropriate march, before the president and addresses the president as follows before retiring to his station:

Vice-President. Sir, I present these candidates for initiation into the (Edisonian Science) Club.

President. The solemnity of the occasion marks this as an hour most fittingly dedicated by prayer. Accordingly, the membership upon the sound of three raps of the gavel shall rise and stand in silence for thirty seconds in token of its foremost obligation to the Creator of all things. Upon the sound of one rap of the gavel all but the candidates shall be seated. . . . Be so governed. (Raps)

(After thirty seconds and following the single rap he continues.) The (Edisonian Science) Club, which is affiliated with the Illinois State Academy of Science, is founded on the ever-enduring cornerstone of Truth. Yesterday, today, and forever, Truth was, is and shall be with us—more certain than Time itself, for it is the material of which Time is made; admired by all; seen only in such degree as we are willing to remember that all things—whether animate, inanimate or spiritual—bear the unmistakable impress of the Divine Creator's hands. It is for us to remember that "knowledge comes, but wisdom lingers"; that it is a part of Man's duty to study, classify, correlate, interpret and build upon the Truths of natural phenomena, for only through such activity may we hope in time to acquire wisdom. "The truth, the whole truth, and nothing but the truth" is the quest of those who propose to follow the beacon light of science. "Only genius can create science", but the humblest man may acquire its spirit. (Pauses) The vice-president will show you in further detail the finishing of this corner stone, this ashlar of Truth. (S).

Vice-President (standing). The Truth is stranger than fiction, and its revelation is worthy of all in all. With Truth as our hammer the Forge of Life will ring for that higher and nobler purpose, the perfect Brotherhood of Man. It is altogether fitting and proper then that you should behold at this time the necessity of truth in all the essential activities of your life (S)—work, play, love and worship—for your success as an individual and as a citizen is not to be measured by worldly wealth but in terms of these four things. Without any one of them success in its fullest sense can not be. (Pauses). The secretary will now instruct you in the object of this organization.

Secretary (standing). The object of this organization shall be to create and foster the best interests of science, to maintain its spirit, to further its methods, to promote relationships between those engaged in scientific work, to assist with investigations and through discussions to make known the material, educational, ar.[1] other resources and riches of the commonwealth, to find in all these activities the vital correlations between the scientific, the social and the moral activities in this school and community. It is for

us to remember that our benefactor (Thomas A. Edison) has through precept and example of work, contributed as largely as any other modern scientist to our present day comfort and happiness. This emblem (pointing to the pin, which he should take care to wear on this occasion and then to the corresponding image on the screen) shall serve as a constant reminder of the wisdom obtained through knowledge; of the power that may come to the individual who walks uprightly and steadfastly by the light of the Truth in scientific, social and moral activities. (Pauses.) The treasurer will inform you concerning the emblematical significance of this organization.

Treasurer (standing). (S.) (Note—The picture involved at this point may be found in R. A. Gregory's, "Discovery, the Spirit and Service of Science," Macmillan, obtained at cost from The Chemical Foundation, Inc., 85 Beaver Street, New York.) It is for me to paint a picture of that which, it is hoped, will remain with you throughout life. It is a portrait not of Science but rather of the Spirit of Science which may be found residing within your personalities. Through this spirit, by lifting a corner of the veil, comes a new breadth of vision; a "new insight into the hidden meaning of things" about you; a growing realization of a greater freedom in the "world, rich in promise and of surpassing interest and wonder". With training, this spirit may be seen in every test tube, detected in the odor of every flower, and heard in the rushing of electrons in obedience to the laws of nature. In all places where man has the privilege of being may the Spirit of Science be found, robed in the blackness of night to signify both the limits of man's vision and the fathomless depths of mystery in which he has found himself. (S) On her extended right hand is borne a white owl, emblematical of the purity and wisdom with which one may hope to look on the future. Clenched in her extended left hand is a lightning bolt symbolical of the command of limitless power. And, lastly, there is to be found coiled about her feet, a large snake indicating health and knowledge as a thing apart from wisdom. This is the Spirit that may be heard to say: "I am what hath been, what is, what shall be. My veil hath been disclosed by none. The fruit which I have brought forth

is this—the sun is born." Ours is the duty and privilege of bringing home to every man, the wonders, the significance, and the underlying or "inner harmony of things of the world in which we live, to the end that all undertakings may be better ordered, all lives enriched, all spirits fortified."

President (to candidates). You have heard the principles upon which this organization is based. Are you ready for the obligation?

Candidates. I am.

President (standing). You will repeat after me: I, (here give your name) do solemnly and sincerely pledge myself to defend the truth as I see it; to serve the best interests of American democracy; to perform faithfully any and all duties entrusted to me by this—or any other—organization in the best interest of science. (Pauses). I am pleased to welcome you as members of the (Edisonian Science) Club. You will now sign the membership roll and take your place among the members.

(After the signatures have been obtained, the president calls for a motion for adjournment).

Following this formal work, there should be a speaker, a regular program, or some film of appropriate nature, among the many possibilities. The following is quoted from a pamphlet, "A Message to High School Students of Illinois from the committee on high school science and clubs, for the year 1922-1923:

"The Council of the Academy authorizes the Committee on High School Science to state that High School Science Clubs may have a copy of the Academy's Transactions on application to the Secretary. The Council also agrees to send to any High School Science Club for its *open meeting*, a speaker of experience. The only cost to the Club will be the speakers' traveling expenses. It is hoped that many Science Clubs will avail themselves of these offers."

REFERENCES—ADDITIONAL.

Meister, Dr. Morris—"Managing a Science Club," School Science and Mathematics, Vol. XXIII., No. 3, March 1923. Note: This paper was read before the Science Section of the N. E. A. Meetings in Boston, July 5, 1922.

"A Suggested Constitution for a Science Club." See pamphlet; "A Message to High School Teachers and Students of Illinois," re-

ferred to above. I suggest addressing C. Frank Phipps, Professor, State Teachers' College, DeKalb, Ill. If unable to locate the material, the writer will supply a modified constitution, on request.

Wiggam, Albert Edward—"The Religion of the Scientist," World's Work, Vol. 50, No. 4, Aug., '25.

Gregory, R. A.—"Discovery, the Spirit and Service of Science," Macmillan. Obtained as one of a set of five books, each worth the total cost, from The Chemical Foundation, Inc., 85 Beaver Street, New York, for the cost of printing; $2.50 the set. This book contains many pictures worthy of use in opaque or other projection in connection with the ritual.

"School Law of Illinois"—Circular No. 202, "Fraternities," An Act to prohibit fraternities, sororities and secret societies in the public schools of the State, and to provide for the enforcement of the same.

The initiation should be performed before the assembly once in four years—in the four years high schools—to conform with the spirit and letter of the law.

Note: For affiliation of clubs address Dr. Lyell J. Thomas, Secretary, Ill. State Academy of Science, University of Illinois, Urbana, Ill., for application

OUTSIDE READING IN SCIENCE IN SECONDARY SCHOOLS.

L. E. HILDEBRAND, NEW TRIER TOWNSHIP HIGH SCHOOL, WINNETKA, ILLINOIS.

The textbook, especially to the poor student, is the Universal symbol of a task imposed much as medicine is prescribed by physicians and hence everything contained therein is labelled with the never-ending "have to" while in outside reading one can give much freedom of choice according to the inclination of the students mind; nor will the future interest of the student be maintained by contact with textbooks, but through the reading of current publications and books of popular interest of the times. It is therefore a crime not to train the young people in wide awake and broad reading. We may *think we* are doing our full duty if we try to hammer the facts of the class text into their minds, but not so, because that leaves them helpless in the library as you will see when you ask them to find certain materials there. Direct them to the index of a volume and they will search the contents—strange how long it takes many of them to learn that distinction. They must become acquainted with books and magazines and even the daily papers, in other words learn how to find what is worthwhile and to the point, of whatever they are trying to do, before they can be considered as having anythink like a proper foundation for an education.

Further, considering the wide scope of science, the fact that one cannot escape from it any more than the Psalmist could get away from God as he says, "Whither shall I go from thy spirit? or whither shall I flee from thy presence? If I ascend into Heaven, thou art there: if I make my bed in Hell, behold thou art there. If I take the wings of the morning and dwell in the uttermost parts of the Sea," etc. Scientific phenomena are around, above, beneath, and even within us; it is therefore almost impossible to fail to find *something* to interest every one who comes under our instruction.

If a student seems totally without interest and completely benighted and entirely incapable of learning anything in the textbook, don't give him up, sound him out and find where his mind *may* find contact with his life's interests or experiences and then assign him, at first, light tasks of reading and let him report before the class, and be sure to bestow praise in some form or other for the work he has done. Repeat this sort of experiment often enough and you will find a student so transformed that he will find the material himself to read and will insist on reporting to the Class; and what is more he will become interested even in the textbook and that is an achievement on the part of a teacher. The next thing you will probably hear about the boy or girl from others is that he or she is singing your praises as a teacher and that is worth something too. Through all this trend of events it must not be forgotten that definite credit must be entered on the class record book for the reading and reporting before the class, and more credit if it is also nicely written up.

The great idea in all this teaching is that there must be a desire to learn and that is acquired by an interest in the subject—*but work bègets interest and reward stimulates work.*

Another good plan in this line is to let some member of the class who becomes so interested in some subject or topic as to show strong signs of inspiration, talk to all the classes thus exposing them all to his "evangelism." Such a procedure always bears fruit. Inspiration is contagious, especially when it comes from one of their own number. I have witnessed some of the most remarkable cases of "evangelistic awakenings" in my own classes. I recall one case especially of a boy who knew more about the habits of honey bees than any other boy of his age I ever knew; and much of it he learned by actual experience with bees. I let him give a regular series of talks to all our Biology Classes; and the very striking thing was the complete command of attention on the part of his listeners who acquired a very extraordinary interest in bees and *that* was a thing worth while.

The case of another boy deserves mention for two reasons. First his very low standing as a student in the

high school and second because of his remarkable ability to talk before his class just as soon as he found something in Biology to interest him. He entered my course and when he showed no signs of interest and seemed little struck with the idea of studying such lowly looking things as grasshoppers and beetles, I took time to find out his likes among living organisms and discovered he was interested in dogs and horses. I gave him a reference and told him to report to the class on the main points of his reading which he did with remarkable success. From this time on his progress was phenomenal. From horses and dogs he went to foxes, wolves, woodchucks, bats etc., and next he began to read entire books beginning with Hornaday's "Vanishing Wild Life", and then "Wild Animals I Have Known". On all these he reported before his class and did it with ever increasing ability. This was grand of course, but his mind had grown so fast during the school year that he now "fell upon" "Men of the Stone Age" by Osborne and here he broke all his former records; he had now found his inspiration so that he could hold his own fellow students to keen attention. He gave it all "straight from the shoulder" and minced no words to soften the meaning; and had Illinois been Tennessee there would have been a change of teachers in the Biology Department before the end of the semester.

To the credit of the community, however, only one complaint came to my notice and that came from the father of the boy. The young man had undertaken to educate the parent and had given him more than he could digest and the first result was resentment and he sent word to the Principal that too much Evolution was being taught for the good of the children. I took the matter up with the boy and told him not to be too persistent with his father, and eventually the boy won out. The father is now an ardent adherent to the Geological conception of time vs. the traditional six-day idea and he never loses an opportunity to tell me that his son got more out of that one study than out of all the rest of his high school course—"it was the making of the boy".

Draw your own conclusion what the result would have been had the textbook method been strictly applied in this case. The fact is he became also a textbook student because

he soon learned to see Biology in a new light and the result was the transformation of the life of a young man.

In conculsion let me say such a thing is easier to talk about than to carry out but it is so *highly* worthwhile that science teachers cannot afford to neglect this sort of training for the weaker students especially.

EQUIPMENT OF THE BIOLOGY LABORATORY IN A SMALL HIGH SCHOOL.

E. V. KENNEDY, AVA COMMUNITY HIGH SCHOOL.

According to a report of the Commission on the Reorganization of Secondary Education, appointed by the National Educational Association, some of the aims in a course in Biology should be: "to develop the pupil's purposeful interest in the life of the environment by giving a first hand acquaintance with plants and animals; train the pupil to observe life phenomena accurately and to form logical conclusions; enrich the life of the pupil through the aesthetic appeal of plants and animals studied, to the end that he may appreciate and enjoy nature."

From a recent textbook on Biology, "Biology will take its place as a valuable subject in training only when teachers require accuracy in observation and the recording of these observed facts in suitable notebooks."

In recent years increasing emphasis has been placed on the study of living organisms. Physiological experiments and ecological studies have been introduced.

It is certainly true that as we attempt to understand nature we must not overlook the fact that the best place to study the plants and animals is in their natural habitat. It is comparatively easy to study plants and animals in their homes throughout the fall and in the spring but during the winter months what study is made of living things must be made in the laboratory. The large high school with a liberal allowance fór the equipment of a laboratory, and some with access to a green house are not so seriously handicapped, but some small high schools with almost nothing but four walls, tables and chairs, find it hard to give the pupils first hand experience with living things. It is to those of this small type of high school that I am hoping this paper will be of some benefit.

For the past few years the project has been recognized as the obvious method for individual work and for group work by students as well. The assignment of projects to be worked out in a scientific manner greatly increases the

value of laboratory work and needs add but little to the expense for equipment. The project method in Biology has not been adopted very generally in small high schools for two principal reasons: First, the necessity for economy; second, too rigid a standardization in laboratory equipment and supplies. This is due partly to requirements made by the State Department and Universities. The first of these causes can easily be eliminated, for as I have stated above the use of projects need not add to the cost of equipment. I will give in the following pages a number of projects carried out in our small high school, some individual and some group, with a very small cost to the school.

During the past two years we have studied in the laboratory the following living specimens: The Cecropia moth has been studied in the egg, caterpillar, cocoon, and adult moth stages. Other moths observed in the laboratory in the caterpillar, cocoon, and adult stages are, the Sphinx Deilephila lineata, and Phlegethontius carolina, Actias luna, Telea polyphemus, and Basilona imperialis. The Monarch butterfly has also been observed in three stages of its life cycle. The Anopheles mosquito has been observed and studied in the egg, larva, pupa and adult stages. The students watched with much interest the development of the mosquito through each of these stages. This animal is particularly interesting to Southern Illinois since about 60% of the malaria of the state was found in twelve counties of Southern Illinois during the years 1922-23 and 24.

Crayfish have been kept throughout the whole school year and we have watched them pass through three molts. The leopard frog has been watched through egg cleavage, blastula and gastrula stages, the tadpole and adult frog. We have kept the common mussel and studied its movements and methods of obtaining food. We have studied the hydra, planaria, water snail, amoeba, paramoecium, and vorticella.

We have grown and observed the following plants: tradescantia, red, variegated, and green species for studying typical closed veination, and effect of chlorophyll in photosynthesis; corn for the study of a typical monocot stem and leaf; ice plant for studying function of epidermis;

beans for studying region of elongation of stems; geraniums for study of typical structure of a leaf and several other plants for various experiments.

All these plants and animals have been kept in the laboratory throughout the school year and pupils have had first hand experience in studying their structure, life history and habits. The total cost of equipment necessary for keeping the above named living specimens amounted to less than five dollars.

An insect cage for hatching and rearing moths and butterflies was made from an orange case donated by a grocer. The two ends of the case made excellent top and bottom to the cage. These were connected by four upright pieces 1 by 2 inches and 30 inches long. Then the three sides were covered with wire screening at a cost of 25 cents. The back was made into a sliding door.

Two window boxes each 4 feet by 1 foot and six inches deep were made from choice cypress and given four good coats of paint. They were placed in south windows on brackets. The total cost of the window boxes was $2.50.

Thirty cents worth of pine lumber made a shelf in another south window 4 feet by 2½ feet, capable of holding ten or twelve eight-inch flower pots.

Our aquarium was made of clear cypress 1 inch by 8 inches. The inside dimensions were 1 foot by 4½ feet and 8 inches deep. This was lined with galvanized tin and carefully soldered. The outside was given two coats of paint. With a shallow layer of sand, gravel and small rocks, this made a comfortable home for frogs, mussels and crayfish.

Stretching boards for mounting insects were made from ½ inch pine board 3 inches wide.

This equipment is listed in a science catalogue at $25.00 and may be made by the pupils themselves for $4.80.

There are lists of standard equipment prepared by scientific companies, State Departments and universities, but all of them contain a large number of articles that a small high school can well get along without. The following

equipment is sufficient for a high school whose classes in Biology are not larger than twelve students:

3 compound microscopes
6 magnifiers
4 ring stands with rings
6 dissection sets
1 section razor
1 hand microtome
6 test tube brushes
6 dissecting pans
2 dozen test tubes
6 battery jars
3 tables (these may be made by local cabinet maker or carpenter)
½ dozen cover glasses
1 dozen pipettes
6 watch glasses
6 evaporating dishes
1 nest beakers
1 thermometer
1 100 cc graduate
6 feet of rubber tubing ¼ inch
filter paper
glass tubing ⅛ to ¼ inch
6 dozen glass slides

CHEMICALS

100 cc eosin
10 grams iodine
1 pound ether
1 pound nitric acid
1 pound sulphuric acid
1 pound hydrochloric acid
1 lb. ammonium hydroxide
1 gallon alcohol
1 gallon formalin
50 grams glycerine
1 pound chloroform
2 lbs. Fehling solution No. 1
2 lbs. Fehling solution No. 2

Another valuable part of the laboratory equipment is the collection of the real things of the natural world, and the preserving of them in the laboratory. Our laboratories may be literally filled with materials that will aid in arousing interest in Natural Science and this is one of the chief ends of the study of Biology.

It is altogether possible to make our laboratory a center of community interest. The interest created in the students will soon spread to members of the community and all will join in acquiring some most interesting material.

A THYROID SURVEY OF THE SCHOOLS OF DECATUR, ILL.

WM. S. KEISTER M. D., HEALTH OFFICER, DECATUR, ILL.

On November 10, 1926, the Commissioner of the State Department of Public Health, Dr. Isaac D. Rawlings, suggested to the writer the advisability of conducting a thyroid survey of the school children of the city of Decatur under the direction of the Decatur Medical Society, with the cooperation of the school authorities, the local health department and the Child Hygiene Division of the State Department of Health, provided all agencies desired the survey. There was no difficulty whatever in securing the full cooperation of all the above groups. The reasons for conducting the survey were two-fold, namely: (1) It was desired to learn whether the prevalence of enlarged thyroids was any greater in Decatur, where the city water supply was free of iodine, than was the case in other places where the water supply contained appreciable amounts of iodine. Unfortunately this comparison cannot be made in this paper as up to this time figures are not available for the latter types of communities: (2) It was desired to determine the actual prevalence of the various degrees of thyroid enlargement among the school children of Decatur, and if possible arrive at some satisfactory method of remedying the condition.

Accordingly Dr. R. C. Cook of the Child Hygiene Division of the State Department of Health arrived in Decatur on February 14, 1927 and the actual work of the survey started the following day. It was soon decided that it would be best to examine all the pupils in all the grades of the public and parochial schools, there being no difficulty whatever in securing the full and sympathetic cooperation of the Board of Education, the authorities in charge of the private and parochial schools, the principals, teachers, nurses and others. The splendid spirit of cooperation of the medical profession is shown by the fact that 28 physicians gave generously of their time during the seven days of the survey. The untiring efforts and ability of Dr. Cook

contributed very largely to the success of the work. The blanks used, based upon those adopted by the U. S. Public Health Service, and others prepared by Dr. Cook, were furnished by the State Department of Health and the Superintendent's office. In order that the results might be fairly uniform, every examiner worked for a time with Dr. Cook to learn his methods and was given a typewritten sheet of instructions. The actual work proceeded so rapidly that it was frequently necessary to rearrange the schedule of schools to be examined each day. The work of tabulation and notification of parents of results found was accomplished by the school nurses, teachers and an assistant from the Superintendent's office, working under the direction of Miss Gunhild Johnson, Supervisor of School Nursing.

There was a total of 10,055 pupils examined in the nine grades of the elementary and junior high schools, together with the sophomore, junior, senior and post-graduate students of the high school. Of this number, 5,338 or 53% showed some degree of thyroid enlargement, there being 4,717 of nearly 47% of normal thyroids. 3,628 (36%) showed a very slight (No. 1) degree of enlargement, 1,509 (15%) slight (No. 2), 187 (1.9%) moderate (No. 3), 10 (.1%) severe (No. 4), and 4 (.04%) very severe enlargement (No. 5). There were 4,854 (48.3%) white boys, 155 (1.5%) colored boys, 4,828 (48%) white girls and 218 (2.2%) colored girls examined.

Prevalence of Thyroid Enlargement According to Grade.

It is interesting to note that the fifth grade had the largest percentage of normal thyroids with 623 out of 1,160 examined (53.7%). The senior class with 121 out of 229 examined (52.8%) was second and the third and sixth grades with 530 and 573 out of 1.014 and 1,092 respectively, (52.7%) tied for third place. Among the very slight (No. 1) degree of enlargement the post-graduate class was highest with 4 out of 5 (80%), the ninth grade with 253 out of 517 (48.9%) second, and the eighth grade with 384 out of 796 (48.2%) third highest. As to the slight (No. 2) degree of enlargement the sixth grade was highest with 402 out of 1,092 (36.8%), the sophomore class with 171 out of 641 (26.7%) second, and the seventh grade with 153

out of 966 (15.8%) third highest. Moderate enlargement (No. 3) was highest in the Junior class with 14 out of 293 (4.8%), the ninth grade with 22 out of 517 (4.3%) second and the senior class with 9 out of 229 (3.9%) third highest. The severe and very severe enlargements (Nos. 4 and 5) were found most prevalent in the Junior class. Thus it is seen that the more marked enlargements, as a rule, were found in the higher grades, although all grades showed a high percentage of very slight enlargement.

According to Sex.

Of the 5,009 boys (white and colored) examined, 2,331 (46.5%) showed some degree of thyroid enlargement. Of the 5,046 girls (white and colored) examined, 3,007 (59.6%) showed some degree of thyroid enlargement. Although the percentage of enlarged glands was highest among the girls the difference (13.1%) between the boys and girls is not as great as is usually supposed. No doubt the difference is greatest among the more marked degrees of enlargement.

According to Color.

Among the 9,682 white boys and girls, there were 5,147 (53.2%) with some degree of enlargement. Among the 373 colored boys and girls there were 191 (51.2%) with some degree of enlargement. The difference between the white and colored pupils was only 2 percent, though this is usually thought to be greater. From the above it is seen that neither color nor sex seems to have a marked influence on the prevalence of enlarged thyroids.

The Remedy.

Questions have been frequently asked as to the best methods of remedying the conditions found in the thyroid survey. This is a rather difficult problem in view of the conflict of opinions among physicians as to the relative merits and supposed dangers of the various treatments advocated. Owing to the fact that simple goiters respond favorably to the various forms of iodine medication, whereas toxic goiters seem to give the opposite effect when treated

with iodine, there have been many theoretical objections raised to the promiscuous use of iodine. However it would seem that very little harm would result in the use of iodine in a wholesale way for school children when we remember that most thyroid enlargements in children are of the simple variety of goiter, which is benefited by this drug. As this question is not yet fully settled, I would like to quote a part of a letter received from Surgeon Robert Oleson, of the U. S. Public Health Service, who has made extensive studies in this field. Dr. Oleson says:

"In replying to our recent goiter questionnaire you asked for information as to the value of iodized table salt and iodized drinking water. Of course a great deal has been written on both of these subjects but so far the results of iodized drinking water are meager in character. It is our intention to prepare an article dealing with the subject of iodization of municipal water supplies and recommend that it be published in the weekly Public Health Reports. So far there appears to be no striking evidence that iodized drinking water is particularly useful in preventing goiter. However, all of the experiments which have been made so far appear to be defective so that a real conclusion cannot be drawn. The method is theoretically correct but there appear to be numerous obstacles in the way of a definite appraisal of its value.

With regard to iodized table salt there is considerable controversy at the present time. Much of the opposition to the use of this commodity comes from Dr. Hartsock of the Crile Clinic in Cleveland. However, he is not alone in assuming that iodized salt is responsible for numerous cases of hyperthyroidism. On the other hand there are numerous striking statements from health officers in the United States and abroad concerning the efficiency of this product as a prophylactic. Experiments are now being made by Dr. Kimball with iodized salt containing 1-20 of the amount of sodium iodide which is used in the Michigan iodized salt. Dr. Kimball informs me that the results following the use of this salt containing minute quantities of iodine are less satisfactory than those obtained from other forms of iodine such as the organic iodide with chocolate.

THYROID SURVEY—DECATUR, ILL.

School	Total Number Examined				Number Enlarged Thyroids				Degree of Enlargement					
	White Boys	White Girls	Colored Boys	Colored Girls	White Boys	White Girls	Colored Boys	Colored Girls	0	1	2	3	4	5
Dennis	140	143	0	0	35	48	0	0	200	56	20	7	0	0
Durfee	505	432	36	38	249	320	25	28	383	394	212	15	1	0
French	93	115	4	10	40	65	2	13	102	80	32	8	0	0
Garfield	165	173	5	5	91	102	1	3	151	168	25	4	0	0
Gastman	131	135	1	11	120	126	0	1	31	164	74	8	1	0
Grant	30	35	0	0	13	20	0	0	32	32	1	0	0	0
Lincoln	163	156	2	1	90	101	1	0	130	156	36	0	0	0
Oakland	103	140	15	14	29	76	3	10	154	108	8	2	0	0
Oglesby	140	152	3	3	45	49	1	2	201	79	13	4	1	0
Pugh	215	186	5	14	80	68	1	1	270	138	9	3	0	0
Riverside	133	136	2	2	50	50	1	0	172	92	8	1	0	0
Roach	421	360	0	0	221	308	0	0	252	328	196	4	1	0
Ullrich	150	149	5	5	64	64	3	1	177	93	29	8	1	1
Warren	196	149	4	8	60	77	2	0	218	115	20	2	1	1
Washington	381	339	36	74	130	117	28	33	522	205	91	10	1	1
St. Johannes	141	136	0	0	114	117	0	0	46	173	52	6	0	0
St. James	105	90	0	0	80	79	0	0	36	100	55	4	0	0
St. Paul	40	26	0	0	8	4	0	0	54	12	0	0	0	0
St. Patrick's	154	113	0	0	77	65	0	0	125	17	121	3	1	0
St. Thomas	67	73	0	0	18	30	0	0	92	32	13	3	0	0
St. Theresa	7	98	0	0	1	49	0	0	55	29	16	5	0	0
7 Day Adventist	11	10	0	0	9	7	0	0	5	3	13	0	0	0
Central Jr	393	410	27	18	229	295	11	5	308	353	141	45	1	0
Roosevelt	445	470	6	7	230	296	3	4	395	341	182	10	0	0
High School	525	602	4	8	163	368	3	5	600	360	142	35	1	1
Total	4854	4828	155	218	2246	2901	85	106	4717	3628	1509	187 5338	10	4
		10055				5338						10055		

TYHROID SURVEY—DECATUR, ILL.

Grades	Total Number Examined				Number Enlarged Thyroids				Decatur	*Distance	Degree of Enlargement						
	White Boys	White Girls	Col. Boys	Col. Girls	White Boys	White Girls	Col. Boys	Col. Girls			0	1	2	3	4	5	Total
1st	658	643	28	33	283	333	9	19	1311	51	718	507	129	6	1	1	1362
2nd	499	529	20	28	246	274	10	19	1021	55	527	441	99	9	0	0	1076
3rd	504	477	18	15	222	238	13	17	975	39	530	387	80	13	3	1	1014
4th	443	421	20	20	221	236	9	9	871	33	429	339	121	15	0	0	904
5th	532	558	8	62	246	269	7	15	1102	58	623	387	128	19	3	0	1160
6th	526	513	27	26	239	253	13	14	1060	32	573	103	402	13	1	0	1092
7th	476	453	17	20	282	327	12	8	885	81	337	449	153	27	0	0	966
8th	378	407	6	5	220	290	4	5	764	32	277	384	109	26	0	0	796
9th	312	197	7	1	123	201	5	1	400	117	187	253	54	22	1	0	517
Soph	313	318	3	7	95	283	3	5	594	47	255	200	171	14	0	1	641
Jun	120	172	1	0	43	111	0	0	263	30	139	105	33	14	1	1	293
Sen	91	137	0	1	25	83	0	0	207	22	121	69	30	9	0	0	229
P. G	2	3	0	0	1	3	0	0	3	2	1	4	0	0	0	0	5
Total	4854	4828	155	218	2246	2901	85	106	9456	599	4717	3628	1509	187 5338	10	4	
			10055				5338			10055				10055			

*Persons living in Decatur less than one year but who were probably not affected by local conditions.

In Cincinnati we are finding considerable less endemic goiter at present than appeared three years ago during our original survey. As iodized table salt has been the only prophylactic recommended in this community it appears at least that the salt may have had some influence upon the simple goiter prevalence in this section."

A few cities, such as Rochester, N. Y. and Minneapolis, Minn. have been using iodine in the public water supply, but, as Dr. Oleson states, the results have not been striking. Akron, Cleveland and other cities have preferred to use Marine and Kimball's method of giving some form of iodine medication to the children for a definite period of time each year, or giving small doses once each week all the time. Various preparations, such as sodium iodide, syrup of the iodides of iron, iodostarine, etc. have been used, the latter being especially popular in some sections, particularly Switzerland. The method most in use is that of iodizing the table salt. Although there have been some objections raised to this method, it would hardly seem to be a means of producing the toxic forms of goiter since the quantity of iodine used is infinitesimal and only takes the place of the normal amount present in the crude salt which is destroyed in refining it. Undoubtedly the latter has been the means of greatly reducing the incidence of the disease in many parts of the country.

CONSTITUTION AND BY-LAWS.

CONSTITUTION AND BY-LAWS

Illinois State Academy of Science.

CONSTITUTION.

ARTICLE I. NAME.

This Society shall be known as THE ILLINOIS STATE ACADEMY OF SCIENCE.

ARTICLE II. OBJECTS.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the science interests of the State.

ARTICLE III. MEMBERS.

The membership of the Academy shall consist of two classes as follows: *National Members* and *Local Members*.

National Members shall be those who are members also of the American Association for the Advancement of Science.

Local Members shall be those who are members of the local Academy only. Each member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of one dollar.

Both national members and local members may be either *Life Members*, *Active Members*, or *Non-resident Members*.

Life Members shall be national or local members who have paid fees to the Academy to the amount of twenty dollars at one time or complete payments before the annual meeting of 1928. The dues from such a source are to be placed as a permanent fund and only the income is to be used. Life members, if national members, shall pay an annual assessment of four dollars.

Active Members shall be national or local members who reside in the State of Illinois.

Non-resident Members shall be active members or life members who have removed from the State of Illinois. Their duties and privileges shall be the same as active members except that they may not hold office.

Charter Members are those who attended the organization meeting in 1908, signed the constitution, and paid dues for that year.

For election to any class of membership, the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

ARTICLE IV. OFFICERS.

The officers of the Academy shall consist of a President, a First Vice-President, a Librarian, a Secretary, and a Treasurer. The Chief

of the Division of State Museum of the Department of Registration and Education of the State Government shall be the Librarian of the Academy. These officers, except the Librarian, shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

A Second Vice-President, who may be a resident of the town in which the next annual meeting is to be held, may be appointed by the council each year when the next meeting place shall have been decided upon.

The above officers shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The Librarian shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, First Vice-President, Second Vice-President, Secretary, Treasurer, Librarian, the retiring president and his immediate predecessor. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

At the Annual Meetings the presiding officer of each of the affiliated scientific societies of the State shall meet with the Academy Council for the discussion of policies.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication, a Committee on Membership and a Committee on Affiliation and such other committees as the Academy shall from time to time deem desirable.

The Committee on Publication shall consist of the President, the Secretary and a third member chosen annually by the Academy.

The committees on Membership and Affiliation shall each consist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council, and shall be called upon written request of twenty members.

Article VIII. Publications.

The regular publications of the Academy shall include the Transactions of the Academy and such papers as are deemed suitable by the Committee on Publications.

All members shall receive gratis the current publications of the Academy.

Article IX. Affiliation.

The academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council, and may be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS.

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meetings of the Academy shall be held without thirty days previous notice by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and the Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Librarian shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. No paper shall be presented at any meeting, by any person other than the author, except on vote of the members present at such meeting. No paper shall be published unless the manuscript be handed to the Secretary within thirty days after the Annual meeting. All papers are limited to twenty pages, additional pages are to be paid for by the author. Except by invitation of the Council, no paper may be accepted for the program unless the author is a member of the Academy or an applicant for membership.

IX. The Secretary and the Treasurer shall have their expenses paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of the council may have their expenses paid while attending meetings of the council, other than those in connection with annual meetings.

X. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

LIST OF MEMBERS.

List of Members

Note—The names of charter members are starred; names in black-faced type indicate membership in the American Association for the Advancement of Science. Numerals in parenthesis after each member indicate the date of joining the Academy.

LIFE MEMBERS.

*Andrews, C. W., LL. D., The John Crerar Library, Chicago, Ill. (Sci. Bibl.) (1908.)
*Bain, Walter G., M. D., St. John's Hospital, Springfield, Ill. (Bacteriology.) (1909.)
Barnes, R. M., LL. B., Lacon, Ill. (Zoology.) (1908.)
*Barnes, William, M. D., 320 Millikin Bldg., Decatur, Ill. (Lepidoptera.) (1908.)
*Bartow, Edward, Ph. D., University of Iowa, Iowa City, Iowa. (1908.)
Bliss, Gilbert Ames, B. S., M. S., Ph. D., 5625 Kenwood Ave., Chicago, Ill. (Math.) (1926.)
Chamberlain, C. J., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1911.)
*Chamberlain, T. C., LL. D., University of Chicago, Chicago, Ill. (Geology.) (1908.)
*Cowles, H. C., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1908.)
*Crew, Henry, Ph. D., Northwestern University, Evanston, Ill. (Physics.) (1908.)
*Crook, A. R., Ph. D., Chief, State Museum, Springfield, Ill. (Geology.) (1908.)
Deal, Don W., M. D., Leland Office Building, Springfield, Ill. (Medicine.) (1908.)
Farrington, O. C., Ph. D., Field Museum, Chicago, Ill. (Mineralogy.) (1908.)
*Fischer, C. E. M., M. D., 25 E. Washington St., Chicago, Ill. (Medicine.) (1908.)
*Forbes, S. A., LL. D., Chief, Natural History Survey, Urbana, Ill. (Zoology.) (1908.)
Fuller, Geo. D., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1912.)
*Gates, Frank C., Ph. D., State Agricultural College, Manhattan, Kansas. (Botany.) (1908.)
Hagler, E. E., M. D., Capitol Ave. and Fourth St., Springfield, Ill. (Occulist.) (1910.)
Hankinson, Thos. L., B. S., State Normal College, Ypsilanti, Mich. (Zoology.) (1908.)
*Hessler, J. C., Ph. D., Knox College, Galesburg, Ill. (Chemistry.) (1908.)
Hoskins, William, 111 W. Monroe St., Chicago, Ill. (Chemistry.) (1908.)
Hunt, Robert I., Decatur, Ill. (Soils.) (1908.)
Jordan, Edwin O., Ph. D., University of Chicago, Ill. (Bacteriology.) (1912.)
Kuntz, Jacob, Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1919).
Latham, Vida A., M. D., D. D. S., 16414 Morse Ave., Chicago, Ill. (Microscopy.) (1909.)
Lillie, F. R., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1912.)
Marshall, Ruth, Ph. D., Rockford College, Rockford, Ill. (Zoology.) (1912.)
Miller, G. A., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.) (1910.)
Moffatt, Mrs. Elizabeth M., 1315 Crown Hill, Los Angeles, Calif. (Zoology.) (1916.)
Moffatt, Will S., M. D., 1315 Crown Hill, Los Angeles, Calif. (Botany.) (1912.)
Mohr, Louis, 349 W. Illinois St., Chicago, Ill. (1909.)
*Noyes, William A., Ph. D., LL. D., University of Illinois, Urbana, Ill. (Chemistry.) (1908.)
*Oglevee, C. S., Sc. D., Lincoln College, Lincoln, Ill. (Biology.) (1908.)
O'Hara, Fred S., M. D., 509 E. N. Grand Ave., Springfield, Ill. (Medicine.) (1925.)
Payne, Edward W., First State Trust & Savings Bank, Springfield, Ill. (Archeology.) (1909.)
*Pepoon, H. S., M. D., Lake View High School, Chicago, Ill. (Zoology, Botany.) (1908.)
Rentchler, Edna K., B. A., Peabody Normal College, Nashville, Tenn. (Biology.) (1912.)
Schaffer, David Nicholas, M. D., 104 S. Michigan Ave., Chicago. (Medicine.) (1925.)
Smith, Frank, M. A., Sc. D., 79 Fayette St., Hillsdale, Mich., (Zoology.) (1909.)
*Smith, Isabel Seymour, 145 Woodland Ave., Oberlin, Ohio. (Botany.) (1908.)
*Smith, L. H., Ph. D., University of Illinois, Urbana, Ill. (Plant Breeding.) (1908.)
Stevenson, A. L., B. S., Field School, 7019 N. Ashland Ave., Chicago, Ill. (1908.)
Stillhamer, A. G., 705 N. East St., Bloomington, Ill. (Physics.) (1908.)
Sykes, Mabel, B. S., South Chicago High School, Chicago, Ill. (Geology.) (1908.)
Trelease, William, LL. D., University of Illinois, Urbana, Ill. (Botany.) (1909.)
Ward, Henry B., Ph. D., Sc. D., University of Illinois, Urbana, Ill. (Zoology.) (1910.)
Washburn, E. W., Ph. D., National Research Council, Washington, D. C. (Chemistry.) (1910.)
Weller, Annie L., Eastern Illinois State Teachers College, Charleston, Ill. (1908.)
Zeleny, Charles, Ph. D., University of Illinois, Urbana, Ill. (Experimental Zoology.) (1910.)

ANNUAL MEMBERS.

Abbott, Howard C., Ph. D., University of South Dakota, Vermillion, South Dakota. (1921.)
Adams, L. A., Ph. D., University of Illinois, Urbana, Ill. (Zoology.) (1923.)
Adams, William A., B. S. A., 2235 N. 75th Ave., Elmwood Park, Ill. (Archeology.) (1927.)
Adams, Roger, Ph. D., 603 Michigan Ave., Urbana, Illinois. (Chemistry.) (1926.)
Adamstone, F. B., M. A., Ph. D., University of Illinois, Urbana, Illinois. (Zoology.) (1926.)
Adler, Herman, M., M. D., 721 S. Wood St., Chicago, Ill. (Medicine.)
Agersborg, H. P. K., Ph. D., James Millikin University, Decatur, Ill. (Zoology.) (1925.)
Aldrich, Frank W., Ph. D., 1506 E. Washington St., Bloomington, Ill. (Anthropology.) (1925.)
Alexander, Alida, M. A., Illinois Woman's College, Jacksonville, Ill. (Botany.) (1918.)
Alexander, C. P., Ph. D., Fernald Hall, Mass. Agr. College, Amherst, Mass. (Entomology.) (1920.)

Alldredge, Samuel M., A. B., P. O. Box 682, Johnston City, Ill. (Chemistry.) (1922.)
Allee, W. C., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1913.)
Alonzo, A. S., M. A., University of Chicago, Chicago, Ill. (Psychology.) (1920.)
Ames, E. S., Ph. D., University of Chicago, Chicago, Ill. (Psychology.) (1920.)
Anderson, Flora, Ph. D., 710 S. Fess Ave., Bloomington, Ind. (Botany.) (1925.)
Appleton, John B., M. S., Ph. D., University of Illinois, Urbana, Ill. (Geography.) (1926.)
Armstrong, Christie, A. B., Princeville, Ill. (Geography.) (1921.)
Arn, William G., B. S., Illinois Central Station, I. C. R. R. Co., Chicago, Ill. (Math., Geology, Physics.) (1927.)
Ashman, George C., Ph. D., Bradley Institute, Peoria, Ill. (Chemistry.) (1913.)
Astell, Louis A., B. A., Box 37, West Chicago, Ill. (Physiology and Hygiene.) (1925.)
*Atwell, Chas. B., Ph. M., Northwestern University, Evanston, Ill. (Botany.) (1908.)
Augur, Allison W., M. A., 5423 Woodlawn, Chicago, Ill. (Physics.) (1921.)
Bacon, Chas. Sumner, Ph. D., M. D., 2333 Cleveland Ave., Chicago, Ill.
Bailey, Mrs. Alice Allen, M. S., University of Chicago, Chicago, Ill. (Botany, Path.) (1927.)
Bailey, Wm. M., M. S., 701 S. Poplar, Carbondale, Ill. (Botany.) (1921.)
Baird, S. H., 708 Woodland Ave., Springfield, Ill. (Chemistry.) (1925.)
Baker, C. J., B. S., 460 E. Ohio St., Chicago, Ill. (Chemistry.) (1926.)
Baker, Frank C., University of Illinois, Urbana, Ill. (Zoology.) (1908.)
Balduf, W. V., Ph. D., 308 Old Law Bldg., University of Illinois, Urbana, Ill. (Entomology.) (1924.)
Banck, Hans J. E., M. E., 1422 Dial Court, Springfield, Ill. (Engineering.) (1925.)
Bangs, Edward H., 212 W. Washington St., Chicago, Ill. (Agriculture and Electricitly.) (1920.)
Barnes, Cecil, LL. B., M. A., 1522 1st National Bank Bldg., Chicago, Ill. (Physical Geography.) (1920.)
Barwell, John Wm., Madison and Sand Sts., Waukegan, Ill. (Anthropology.) (1908.)
Bastin, E. S., Ph. D., University of Chicago, Chicago, Ill. (Geology.) (1925.)
Bates, Onward, LL. D., 332 S. Michigan Ave., Chicago, Ill. (Civil Engineering.) (1926.)
Bauman, Harold Ed. B., Farina, Ill. (Zoology.) (1926.)
*Bayley, W. S., Ph. D., University of Illinois, Urbana, Ill. (Geology.) (1908.)
Beal, James Hartley, Sc. D., 801 Nevada, Urbana, Ill. (Medicine.) (1916.)
Beecher, Wm. L., M. D., Ph. D., 25 E. Washington St., Chicago, Ill. (Medicine.) (1927.)
Behre, Chas. H., Jr., Univ. of Cincinnati, Cincinnati, Ohio. (1921.)
Bell, Alfred H., Ph. D., University of Illinois, Urbana, Ill. (Geology.) (1927.)
Bell, Marie, Box 114, Albany, Indiana. (Biology.) (1926.)
Bengel, George A., 808 S. 4th St., Springfield, Ill. (Engineering.) (1925.)
Bentley, Madison, Ph. D., University of Illinois, Urbana, Ill. (Psychology.) (1920.)
Benton, Curtis, B. A., Macomb, Ill. (Entomology.) (1925.)
Bergman, Ross M., 613 S. Hale St., Wheaton, Ill. (Biology.) (1926.)
*Betten, Cornelius, Ph. D., Cornell University, Ithaca, N. Y. (Biology.) (1908.)
Bevan, Arthur, Ph. D., 248 Nat. Hist., University of Illinois, Urbana, Ill. (Geology.) (1924.) (1924.)
Bigger, J. H., B. S., 305 N. Prairie, Ave., Jacksonville, Ill. (Entomologist.) (1925.)
Black, Arthur D., M. D., D. D. S., Northwestern University, Evanston, Ill. (Dentistry.) (1921.)
Blackstock, Ira B., M. A., 213 E. Jefferson St., Springfield, Ill. (Agriculture.) (1925.)
Blair, Mary Constance, Ph. D., 1011 Grove St., Evanston, Ill. (Botany and Zoology.) (1926.)
Blake, Anna M., B. S., 409 W. Willow St., Normal, Ill. (Botany and Physiology.) (1917.)
Blake, Mrs. Tiffany, 25 East Walton Place, Chicago, Ill. (1921.)
Blanchard, W. O., Ph. D., 305 Washington Blvd., Urbana, Ill. (Geography.) (1925.)
Bleininger, A. V., B. S., Homer Laughlin China Co., Newell, W. Va. (Ceramics.) (1908.)
Block, D. Julian, Ph. D., 222 E. Ontario, Chicago, Ill. (Chemistry.) (1920.)
Bohannon, F. C., B. S., Galesburg High School, Galesburg, Ill. (Geography and Geology.) (1924.)
Bonnell, Clarence, Township High School, Harrisburg, Ill. (Biology.) (1926.)
Boomer, S. E., M. A., 207 Harwood St., Carbondale, Ill. (Physics.) (1921.)
Boos, Mrs. Margaret Fuller, Ph. D., Care of Empire Gas & Fuel Co., Bartlesville, Okla. (Geology.) (1924.)
Boot, G. W., M. D., 813 Sherman Ave., Evanston, Ill. (Medicine and Geology.) (1920.)
Bracken, Ellis F., B. S., 7003 Eggleston Ave., Chicago, Ill. (Physics.) (1927.)
Brannon, James Marshall, Ph. D., University of Illinois, Urbana, Ill. (Plant Physiology Cytology and Bacteriology.) (1926.)
Breed, Frederick S., Ph. D., 5476 University Ave., Chicago, Ill. (Education.) (1921.)
Bregowsky, Ivan M., 4600 W. Harrison St., Chicago, Ill. (Chemistry and Metallurgy.) (1926.)
Bretz, J. Harlan, Ph. D., University of Chicago, Chicago, Ill. (Geology.) (1921.)
Brokaw, Raymond Voorhees, M. D., 1001 S. Second St., Springfield, Ill. (Medicine.) (1925.)
Brown, Agnes, 1205 W. State St., Rockford, Ill. (1921.)
Brown, George A., 304 E. Walnut St., Bloomington, Ill. (Education.) (1920.)
Brown, H. Clark, B. S., 409 Hamilton St., St. Charles, Ill. (Botany.) (1924.)
Browne, George M., 902 S. Normal St., Carbondale, Ill. (Chemistry.) (1921.)
Brundage, John T., A. B., A. M., Univ. of Ill., Urbana, Ill. (Physiological Chem.) (1927.)
Buckingham, B. R., Ph. D., Director of Bureau of Educational Research, Ohio State University, Columbus, Ohio. (Education.) (1920.)
Burmeister, Wm. H., M. D., 536 Deming Place, Chicago, Ill. (Experimental Medicine.) (1920.)
Buswell, A. M., Ph. D., Chief, State Water Survey, University of Illinois, Urbana, Ill. (1921.)
Buzzard, Robt. G., M. S., Ill., 608 Normal Ave., Normal, Ill. (Geography and Geology.) (1922.)

Cahn, Alvin R., Ph. D., University of Illinois, Urbana, Ill. (Zoology.) (1925.)
Caldwell, Delia, M. D., 590 W. Main St., Carbondale, Ill. (Medicine.) (1921.)
Cammack, R. R., B. S., 200 E. Blvd., Marion, Ill. (Chemistry.) (1926.)
Campbell, Ian, M. A., Louisiana State University, Baton Rouge, La. (Geology.) (1925.)
Card, H. H., Botany Department, University of Illinois, Urbana, Ill. (Botany.) (1925.)
Carleton, Ralph Pimball, M. A., 3012 Edwards St., Alton, Ill. (Chemistry.) (1926.)
Carlson, A. J., Ph. D., University of Chicago, Chicago, Ill. (Physiology.) (1911.)
Carlson, Fred, E. B., State Teachers College, DeKalb, Ill. (Geography.) (1923.)
•**Carman, Albert P.**, Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1908.)
•**Carpenter, Chas. K.**, D. D., Baileyville, Ill. (Ornithology.) (1908.)
Causey, David, Ph. D., Zoology Department, Princeton University, Princeton, N. J. (Biology.) (1922.)
Caven, Jordon, M. A., Rockford College, Rockford, Ill. (Psychology.) (1926.)
Challis, Frank E., 121 N. Wabash Ave., Chicago, Ill. (Chemistry.) (1921.)
Chandler, S. C., B. S., Carbondale, Ill. (Entomology.) (1921.)
Chapman, Hazel, 301 W. Washington St., Urbana, Ill. (Zoology.) (1925.)
•**Child, C. M.**, Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1908.)
Christie, J. R., B. S., East Falls Church, Va. (Biology.) (1929.)
Clark, Albert Henry, B. S., 701 W. Wood St., Chicago, Ill. (Chemistry.) (1920.)
Clark, H. Walton, M. A., California Academy of Sciences. Golden Gate Park, San Francisco, Calif. (Biology.) (1917.)
•**Clawson, A. B.**, B. A., Dept. of Agri., Washington, D. C. (Biology.) (1908.)
Cletcher, J. O., M. D., 10 N. Main St., Tuscola, Ill. (Medicine.) (1921.)
Clute, W. N., Editor, "The American Botanist," Joliet, Ill. (Botany.) (1918.)
Coale, Henry K., Highland Park, Illinois. (Ornithology.) (1926.)
Coffin, Fletcher B., Ph. D., Lake Forest, Ill. (Physical Chemistry.) (1911.)
Coggeshall, Ruth, B. S., 3927 N. Hamlin Ave., Chicago, Ill. (Biology.) (1924.)
Colby, Arthur Samuel, Ph. D., University of Illinois, Urbana, Ill. (Horticulture.) (1920.)
Colby, Chas. C., Ph. D., University of Chicago, Chicago, Ill. (Geography.) (1920.)
Cole, Fay-Cooper, B. S., Ph. D., 5710 Blackstone, Chicago, Ill. (Anthropology.) (1927.)
Cole, Herman H., M. D., 517 E. Capitol Ave., Springfield, Ill. (Medicine.) (1915.)
Colyer, F. H., M. S., State Normal University, Carbondale, Ill. (Geography.) (1915.)
Combs, Ralph Marion, 1106 Natchitoches, La. (Biology.) (1924.)
Compton, James S., Eureka, Ill. (1914.)
Cox, F. W., M. A., Clark University, Worchester, Mass. (Geography.) (1926.)
•**Crandall, Chas. S.**, University of Illinois, Urbana, Ill. (Horticulture.) (1908.)
Crandle, Ellis R., Ed. B., 509 S. Poplar, Carbondale, Ill. (Biology.) (1927.)
Crathorne, A. R., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.) (1920.)
Creager, Gail, Ed. B., Pinckneyville, Ill. (Biology.) (1924.)
Cribb, Aubrey, "The Associated Press," Springfield, Ill. (1921.)
Crompton, Mabel, M. S., 310 Normal Ave., Normal, Ill. (Geography.) (1927.)
Crosier, W. M., M. D., Alexis, Ill. (Medicine.) (1921.)
Crowe, A. B., M. A., Eastern State Teacher's College. Charleston, Ill. (Physics.) (1910.)
Croxton, Orson, B. S., Ed., 413 E. Cherry St., Watseka, Ill. (Chemistry.) (1927.)
Crummer, Mrs. Emma C., 134 S. Kenillworth Ave., Oak Park, Ill. (Botany.) (1925.)
Culler, Elmer A., Ph. D., University of Illinois, Urbana, Ill. (Psychology.) (1927.)
Cullison, Aline, 7855 South Shore Drive, Chicago, Ill. (Biology.) (1923.)
Curran, Gordon, C., B. S., 407 W. Illinois St., Urbana, Ill. (Botany.) (1925.)
Currens, Frederick Hawley, Ph. D., 130 N. Normal St., Macomb, Ill. (Chemistry.) (1914.) (1926.)
Curtis, George M., B. A., M. A., Ph. D., M. D., Billings Hospital, Univ. of Chicago, Chicago, Ill. (Anatomy.) (1927.)
Darling, Elton R., Ph. D., 1293 W. Macon Ave., Decatur, Ill. (1920.)
Dart, Carlton R., 706 Greenleaf Ave., Wilmette, Ill. (Civil Engineering.) (1921.)
Davenport, Eugene, LL. D., Woodland, Mich. (Agriculture.) (1910.)
Davies, D. C., Director, Field Museum, Chicago, Illinois. (1921.)
•Davis, J. J., B. S., Purdue University, Lafayette, Ind. (Entomology.) (1908.)
Day, William B., Ph. G., 715 S. Wood St., Chicago, Ill. (Botany.) (1927.)
Deam, Hon. Chas. C., M. A., Bluffton, Ind. (Forestry and Flora.) (1921.)
Dean, Ella R., B. Ed., 221 S. Mill St., Olney, Ill. (Chemistry.) (1921.)
Deffenbaugh, R. A., B. S., 630 W. Edwards St., Springfield, Ill. (Physics.) (1925.)
DeLee, Jos. B., M. A., 5028 Ellis Ave., Chicago, Ill. (1921.)
DeLoach, R. J. H., M. A., 5541 Dorchester, Chicago, Ill. (Botany, Soils, Economics.) (1926.)
Dempster, A. J., Ph. D., University of Chicago, Chicago, Ill. (Physics.) (1921.)
De Ryke, Willis, Ph. D., 1051 Grove, Jacksonville, Ill. (Biology.) (1927.)
De St. Cyr, William H., D. O., 30 N. Michigan Ave., Chicago, Ill. (Medical Sci. & Physics.) (1927.)
DeTurk, Ernest E., Ph. D., 707 W. Green St., Urbana, Ill. (Agriculture.) (1920.)
Dilts, Charles D., A. B., 3121 Fairfield Ave., Ft. Wayne, Ind. (Chemistry.) (1921.)
Dodge, Lawrence E., B. S., 500 Broadway, Gillespie, Ill. (Chemistry.) (1926.)
Donoghue, Julia O., 5538 Magnolia, Chicago, Ill. (Nature Study.) (1927.)
Doolittle, Kilus, B. S., 313 W. Walnut St., Harrisburg, Ill. (Biology.) (1926.)
Downie, Thos. R., 1216 N. Kellogg St., Galesburg, Ill. (Geology.) (1923.)
Downing, Eliot R., Ph. D., University of Chicago, Ill. (Zoology.) (1913.)
Dufford, R. T., University of Missouri, Columbia, Mo. (Physics.) (1918.)
Dungan, Geo. H., B. S., M. S., Ph. D., University of Ill., Urbana, Ill. (Plant physiology.) (1927.)
Earle, C. A., M. D., DesPlaines, Ill. (Botany.) (1920.)
East, Clarence W., M. D., F. A. S. C., 326 W. Jackson St., Springfield, Ill. (Preventive Medicine.) (1921.)
Eaton, Scott V., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1925.)
Eddy, Samuel, M. A., Vivarium Bldg., University of Illinois, Urbana, Ill. (Biology.) (1925.)
Edwards, Linden F., B. A., M. S., 301 Nat. Hist. Bldg., University of Illinois. Urbana, Ill. (Zoology.) (1926.)

Ehrman, E. H., M. E., Homan Ave. and Fillmore St., Chicago, Ill. (1920)
Eifrig, C. W. G., 504 Monroe Ave., River Forest, Ill. (Ornithology, Botany, Zoology.) (1920.)
Ekblaw, George Elbert, A. M., 308 Lincoln, Urbana, Ill. (Geology.) (1924.)
Ekblaw, W. E., Ph. D., Clark University, Worchester, Mass. (Geology.) (1908.)
Eklund, Edwin G., M. A., 1451 S. Lincoln St., Springfield, Ill. (Psychology.) (1925.)
Eldredge, Arthur G., University of Illinois, Urbana, Ill. (Photography.) (1916.)
Ellison, Lewis M., 214 W. Kinzie St., Chicago, Ill. (Engineering.) (1927.)
Eller, W. H., S. B., 230 N. Ward St., Macomb, Ill. (Physics.) (1924.)
Englis, Duane T., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.) (1917.)
Esmaker, John Benjamin, M. A., 1076 W. Roosevelt Road, Chicago, Ill. (Physics.) (1926.)
Evans, Frank N., M. D., 407 S. Seventh St., Springfield, Ill. (Medicine.) (1925.)
Ewing, H. E., U. S. Nat. Museum, Washington, D. C. (Biology.) (1908.)
Falk, I. S., Ph. D., University of Chicago, Chicago, Ill. (Bacteriology and Hygiene.) (1925.)
Farnam, Bertha L., Carbondale, Ill. (Biology.) (1927.)
Fasoldt, Karl N., B. Ph., Johnston City, Ill. (Botany.) (1927.)
Faught, Eva E., 841 S. English Ave., Springfield, Ill. (Bacteriology.) (1925.)
Faust, Mildred E., M. S., 848 Lancaster Ave., Syracuse, N. Y. (Botany.) (1925.)
Ferguson, Harry F., S. B., Dept. Public Health, Springfield, Ill. (Sanitary Engineer.) (1925.)
Fetter, Dorothy, M. S., Rockford College, Rockford, Ill. (Physiology.) (1926.)
Feuer, Bertram, M. S., 2634 Argyle St., Chicago, Illinois. (Chemistry and Bacterology.) (1921.)
Finley, C. W., M. A., State College of Education, Upper Montclair, N. J. (Zoology.) (1910.)
Fisher, D. Jerome, Ph. D., Rosenwald Hall, University of Chicago, Chicago, Ill. (Geology.) (1926.)
*Fisher, Fannie, Ass't Curator, State Museum, Springfield, Ill. (General Interest.) (1908.)
Fiske, David, M. S., Amer. Soc. Refrigerating Engineers, 29 W. 29th St., New York, N. Y. (Physics.) (1926.)
Flint, W. P., Ass't State Entomologist, 1006 S. Orchard St., Urbana, Ill. (Entomology.) (1914.)
Foberg, J. Albert, B. S., Camp Hill, Pa. (Mathematics.) (1917.)
Folsom, Justus W., Sc. D., Tallulah, La. (Entomology.) (1916.)
Foreman, Blye E., B. E., 801 Hester Ave., Normal, Ill. (Zoology.) (1927.)
Franing, E. C., M. D., 404 Bank of Galesburg Bldg., Galesburg, Ill. (Medicine.) (1921.)
Franing, Russell, A. B., Dundee Community High School, Dundee, Ill. (Chemistry.) (1924.)
Frank, O. D., 6207 Kimbark Ave., Chicago, Ill. (Biology.) (1918.)
Freeman, Harriette, M. S., 111 S. Eastern, Joliet, Ill. (Botany.) (1927.)
French, G. H., M. A., Herrin Hospital, Herrin, Ill. (Botany and Entomology.) (1921.)
Frison, Theodore H., Ph. D., 316-A-Natural History Bldg., University of Illinois, Urbana, Ill. (Entomology, General Biology.) (1917.)
Fryxell, Fritiof M., M. A., 715 3rd St., Moline, Ill. (Geology.) (1925.)
Funk, Donald S., B. A., Sangamo Electric Co., Springfield, Ill. (1925.)
Gamble, Faith, 206 Clintin Ave., Oak Park, (1926.)
Gantz, R. A., 411 N. Talley St., Muncie, Ind. (Botany.) (1917.)
Garnett, H. W., B. S., Bloomington, Ill. (Chemistry.) (1927.)
Gault, B. T., 564 N. Main St., Glen Ellyn, Ill. (Ornithology.) (1910.)
Gawlt, Robert H., Ph. D., Northwestern University, Evanston, Ill. (Psychology.) (1926.)
Gay, Berry E., Ph. G., 720 W. Olive St., Decatur, Ill. (Bacteriology.) (1927.)
Geauque, H. A., Lombard St., Galesburg, Ill. (Chemistry.) (1923.)
Gerhard, Wm. J., Field Museum, Chicago, Ill. (1908.)
Gerould, T. P., M. D., 115½ N. Locust St., Centralia, Ill. (Medicine.) (1921.)
Gersbacher, Willard M., Ed. B., 301 Nat. Hist. Bldg., Urbana, Ill. (Zoology.) (1926.)
Givens, Harry V., B. S., Midland Ave., Joliet, Ill. (Biology.) (1927.)
Glattfeld, J. W. E., Ph. D., Kent Chemical Laboratory, University of Chicago, Chicago, Ill. (Chemistry.) (1921.)
Goldstine, Mark T., M. D., L. M., Chicago, Ill. (Medicine.) (1926.)
Goode, J. Paul, Ph. D., 6227 Kimbark Ave., Chicago, Ill. (Geography.) (1912.)
Gore, G. W., M. D., 231 N. McCleamsboro St., Benton, Ill. (Internal Med.) (1921.)
Gorrell, T. J. H., M. D., Chicago Heights, Ill. (Medicine.) (1921.)
Gould, Prof. Wm. C., M. A., 625 DeKalb Ave., DeKalb, Ill. (Geography.) (1925.)
Gradle, Harry S., M. D., 22 E. Washington St., Chicago, Ill. (Opthalmology.) (1920.)
Graham, Robert, B. S., D. V. M., 105 Animal Pathology, University of Illinois, Urbana, Ill. (Pathology.) (1910.)
Graham, V. O., M. S., 4028 Grace St., Chicago, Ill. (Botany.) (1926.)
*Grant, U. S., Ph. D., Northwestern University, Evanston, Ill. (Geology.) (1908.)
Greathouse, G. A., B. E., West Salem, Ill. (Biology.) (1927.)
Green, Bessie, M. A., Oregon State Agr. Coll., Corvallis, Ore. (Zoology.) (1911.)
Green, Helen R., A. B., 309 W. Church St., Benton, Ill. (1927.)
Greenman, J. M., Ph. D., Missouri Botanical Garden, St. Louis, Mo. (Botany.) (1911.)
Greer, Frank E., A. B., M. S., 5458 Kimbark Ave., Chicago, Ill. (Bacteriology.) (1927.)
Griffin, J. P., A. B., 909½ S. Fifth St., Champaign, Ill. (Geology.) (1927.)
Griffith, Coleman R., Ph. D., University of Illinois, Urbana, Ill. (Psychology.) (1920.)
Gronemann, Carl F., 310 N. Liberty St., Elgin, Ill. (Artist, Naturalist.) (1921.)
Grove, P. F., M. A., 603 E. Ridge St., Mt. Carroll, Ill. (Botany.) (1926.)
Gurley, William F. E., 6151 University Ave., Chicago, Ill. (Paleontology.) (1908.)
Haas, William H., M. A., Northwestern University, Evanston, Ill. (Geography.) (1914.)
Haefuer, R., M. A., 1538 4th St., Charleston, Ill. (Psychology.) (1926.)
Hagler, Mrs. E. S., 1900 W. Lawrence Ave., Springfield, Ill. (1910.)
*Hale, John A., M. D., 117½ W. Ninth St., Los Angeles, Calif. (Medicine.) (1908.)
Hamilton, Angelina G., M. D., State Hospital, Anna, Ill. (Psychiatry.) (1926.)
Hamp, Mattie S., Rosiclare High School, Rosiclare, Ill. (Biology.) (1926.)
Hanke, Martin E., S. B., Ph. D., 8424 Rhodes Ave., Chicago, Ill. (Physiology and Chem.) (1927.)
Hanks, Mary E., M. D., 307 N. Michigan Ave., Chicago, Ill. (Roentgentheraphy.) (1927.)
Hansen, Paul, 9741 Avenue H, Chicago, Ill., (Geology.) (1927.)

Hansen, Paul, 6, No. Michigan Ave., Chicago, Ill. (Sanitation.) (1913.)
Hardin, Sarah M., Ph. B., 402 W. Walnut St., Carbondale, Ill. (Biology.) (1924.)
Harding, H. A., Ph. D., 685 Mullett St., Detroit, Mich. (Bacteriology.) (1916.)
Harland, Marion B., B. S., 655 Old Agriculture Bldg., University of Illinois. Urbana, Ill. (Soils.) (1925.)
Hartman, Ernest, B. S., M. S., Sc. D., 602 W. High, Urbana, Ill. (Parasitology.) (1927.)
Hartsough, Ralph C., A. M., 3808 Grove Ave., Berwyn, Ill. (Biology.) (1922.)
Harvey, Alice L., B. A., 2036 Spruce St., Murphysboro, Ill. (Chemistry.) (1926.)
Hauberg, John H., B. S., LL. B., 23rd St. Hill and 13th Ave., Rock Island, Ill. (Botany.) (1921.)
Hauberg, Mrs. John H., 23d St., Hill and 13th Ave., Rock Island, Ill. (1921.)
Haupt, Arthur W., University of California, Los Angeles, Calif. (Botany.) (1912.)
Hawkes, Joseph Bulkley, A. B., 825 N. Church St., Rockford, Ill. (Botany.) (1925.)
Hawley, Gladys, B. S., Editor, State Geological Survey, Urbana, Ill. (Geology.) (1926.)
Hawthorne, W. C., B. S., 1410 E. 58th St., Chicago, Ill. (1908.)
Hay, Logan, B. A., 1220 S. Grand Ave., W., Springfield, Ill. (Mathematics.) (1925.)
Hayes, Wm. P., Ph. D., 306 Old Law Bldg., Urbana, Ill. (Entomology.) (1926.)
Hazell, E. F., D. D. S., 608 E. Capitol Ave., Springfield, Ill. (Meteorology.) (1925.)
Hedrick, Leslie, A. B., 410 Conover Ave., Eureka, Ill. (Zoology.) (1927.)
Heflin, H. N., M. D., Kewanee, Ill. (Medicine.) (1921.)
Hemenway, Henry B., M. D., 620 Amos Ave., Springfield, Ill. (Public Health.) (1918.)
Henbest, Lloyd G., A. B., 305 Ceramics Bldg., Univ. of Ill., Urbana, Ill. (Geology and Biology.) (1927.)
Henderson, Lena B., M. S., Rockford College, Rockford, Ill. (Botany.) (1926.)
Henderson, Luther B., M. A., B. D., 176 Woodlawn Ave., Decatur, Ill. (Psychology.) (1925.)
Hendrickson, Eliz., B. S., 3501 Montrose Ave., Chicago, Ill. (Botany.) (1926.)
Henkel, H. B., M. D., 401 E. Capitol Ave., Springfield, Ill. (Medicine.) (1925.)
Herndon, R. P., 407 S. Seventh St., Springfield, Ill. (Medicine.) (1925.)
Herrick, C. Judson, Ph. D., University of Chicago, Chicago, Ill. (Anatomy.) (1920.)
Herrick, Julia F., M. A., Mayo Foundation, Rochester, Minn. (Physics.) (1926.)
Herron, James C., 1417 W. Jackson Blvd., Chicago, Ill. (Illuminating Engineer.) (1926.)
Hieronymus, R. E., LL. D., 109 New Agricultural Bldg., University of Illinois. Urbana, Ill. (1926.)
Higgins, George M., Ph. D., Inst. Experimental Medicine, Rochester, Minn. (Zoology.) (1921.)
Higginson, Glenn D., Ph. D., 1117 W. Illinois St., Urbana, Ill. (Psychology.) (1927.)
Higley, L. A., Ph. D., Box 336, Wheaton, Ill. (Chemistry.) (1926.)
Hildebiand, L. E., M. A., New Trier Township High School, Winetka, Ill. (Zoology.) (1911.)
*Hill, W. K., Carthage College, Carthage, Ill. (Biology.) (1908.)
Hinchliff, Grace F., 715 N. Broad St., Galesburg, Ill. (1916.)
Hines, Murray A., Ph. D., 1416 Hinman Ave., Evanston, Ill. (Chemistry.) (1914.)
Hinrichs, Marie A., Ph. D., University of Chicago, Chicago, Ill. (General Physiology.) (1926.)
Hockenyos, Geo. L., 1003 Oregon St., Urbana, Ill. (Botany.) (1927.)
Hoffman, Frand F., M. D., 3117 Logan Blvd., Chicago, Ill. (Phys. Surg.) (1921.)
Holzate, T. P., LL. D., 617 Library St., Evanston, Ill. (Mathematics.) (1908.)
Holmes, Harriet F. (Miss), A. B., South Batavia Rd., Batavia, Ill. (Plant Pathology.) (1927.)
Holmes, Leslie A., 249 Nat. Hist. Bldg., University of Illinois, Urbana, Ill. (Geology.) (1926.)
Holmes, Manfred J., B. L., 703 Broadway, Normal, Ill. (Social and Education.) (1920.)
Holmes, Ralph R., M. D., 458 W. 61 St., Chicago, Ill. (Astronomy.) (1926.)
Holtz, F. C., B. S., 1358 Dial Court, Springfield, Ill. (Mathematics.) (Physics.) (1925.)
Honey, Edwin E., B. S., 2028 Monroe St., Madison, Wis. (Plant Pathology, Botany, Entomology.) (1921.)
Hopkins, B Smith, Ph. D., 706 W. California St., Urbana, Ill. (Inorganic Chemistry.) (1920.)
Hopkins, Frank, Makanda, Illinois. (Optometry.) (1926.)
Horrell, C. R., B. S., Sangamo Electric Co., Springfield, Ill. (Electrical Engineering.) (1925.)
Hottes, C. F., Ph. D., University of Illinois, Urbana, Ill. (Botany.) (1908.)
Howe, Samuel W., Ed. B., 311 N. 14th St., Herrin, Ill. (1925.)
Howe, T. D., Ph. D., 1310 W. Main, Decatur, Ill. (Botany.) (1925.)
Hudelson, C. W., M. S., 206 S. Main St., Normal, Ill. (Agriculture.) (1921.)
Huey, Walter B., M. D., Elgin, Joliet & Eastern Ry., Joliet, Ill. (Medicine.) (1921.)
Hufford, G. N., A. B., 216 Seeser, Joliet, Ill. (Botany.) (1927.)
Hull, Thos. G., Ph. D., State Board of Health, Springfield, Ill. (Health.) (1921.)
Hungerford, Warren, H., 1920 City Hall Square Bldg., Chicago, Ill. (Physics.) (1927.)
Hunter, George W., Ph. D., 210 Mesa Ave., Claremont, Calif. (Biology.) (1921.)
*Hutton, J. Gladden, M. S., State College, Brookings, S. D. (Geology.) (1908.)
Illinois State Library, State House, Springfield, Ill. (1921.)
Isenbarger, Jerome, B. S., 2200 Greenleaf Ave., Chicago, Ill. (Zoology.) (1921.)
Jackson, George H., Jr., M. D., 310 S. Michigan Ave., Chicago, Ill. (Medicine.) (1926.)
Jacobi, Wm. H., M. E., Springfield Boiler Co., Springfield, Ill. (Physical Chemistry.) (1925.)
Jacobs, Margaret C., 413 Leland St., Baraboo, Wis. (Botany.) (1925.)
Jane, Wm. T., 5 N. Wabash Ave., Chicago, Ill. (Bausch & Lomb Opt. Co.) (1921.)
Janson, Ardylle A., 636 Church St., Evanston, Ill. (Bacteriology.) (1927.)
Jelliff, Fred R., B. A., Editor, Daily Republican-Register, Galesburg, Ill. (Geology.) (1917.)
Jenks, Ira J., M. S., State Teachers College, DeKalb, Ill. (Chemistry.) (1922.)
Jensen, Jens, Ravinia, Ill. (Geology-Botany.) (1921.)
Johnson, George P., 625 Black Ave., Springfield, Ill. (Astronomy.) (1914.)

Johnson, John H., B. Ed., Supt. of Schools, Tremont, Ill. (Biology.) (1923.)
Johnson, T. Arthur, M. D., 503 7th St., Rockford, Ill. (Medicine, Science and Surgery.) (1920.)
Jones, Elmer E., Ph. D., Northwestern University, Evanston, Ill. (Mental Development-Heredity.) (1920.)
Jurica, Hilary S., St. Procopius College, Lisle, Ill. (Botany.) (1922.)
Kaplan, Bertha, M. S., B. S., 1350 S. Avers Ave., Chicago, Ill. (Bacteriology and Parasitology.) (1927.)
Karr, Gertrude, B. A., Fredericksburg, Va. (Botany.) (1925.)
Karraker, Edward L., Jonesboro, Ill. (Forestry.) (1921.)
Kauffman, J. S., M. D., 5605 Woodlawn Ave., Chicago, Ill. (Medicine.) (1920.)
Kelsey, Alice B., A. M., So. Ill. State Normal, Carbondale, Ill. (Mathematics.) (1926.)
Kelso, Margut A., 6 Cedar Crest, Normal, Ill. (Chemistry.) (1925.)
Kempton, F. E., M. S., Centerville, Ind., (Plant Pathology.) (1917.)
Kennedy, E. V., Ed. B., Ava, Ill. (Biology.) (1925.)
Kennicott, Ransom, 547 Cook Co. Bldg., Chicago, Ill. (Forestry.) (1921.)
Kent, R. A., Ph. D., 625 Emerson St., Evanston, Ill. (Education.) (1926.)
Keyes, D. B., B. A., M. A., Ph. D., 107 Chem. Bldg., Urbana, Ill. (Chemistry.) (1927.)
Kibbe, Alice L., Denhart Hall, Carthage, Ill. (Botany.) (1925.)
Kienholz, Aaron Raymond, Ph. D., 606 Washington St., Urbana, Ill. (Botany.) (1925.)
Kirkpartick, Amy R., Anna, Ill. (Artist.) (1926.)
Kirn, George H., Ph. D., D. D., Northwestern College, Naperville, Ill. (Psychology and Philosophy.) (1923.)
Kline, R. G., M. D., Hoopeston, Ill. (Medicine.) (1921.)
*Kneale, Elmer J., Ill. State Register, Springfield, Ill. (Astronomy.) (1908.)
***Knipp, Charles T.**, Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1908.)
Koch, Fred Conrad, Ph. D., University of Chicago, Chicago, Ill. (Physiological Chemistry.) (1920.)
Koontz, D. Lionel, 902 Reba Place, Evanston, Ill. (Mechanical Engineer.) (1926.)
Kordiemon, Anna M., 825 Washington, Quincy, Ill. (1926.)
Krause, Heinrich, D. D. L., 2938 Normal Ave., Chicago, Ill. (Anthropology.) (1926.)
Krenz, Mathilde H., B. A., A. M., 1002 W. Oregon St., Urbana, Ill. (Botany.) (1925.)
Kuh, Sidney, M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.) (1911.)
Lackie, G. D., M. D., Springfield, Ill. (Medicine.) (1927.)
Lacy, Robert, M. E., 1354 Dial Court, Springfield, Ill. (Engineer.) (1925.)
Lake, Bae M., B. E., 203 Grand Ave., Lincoln, Ill. (Biology.) (1927.)
Lamar, J. Everts, B. S., State Geological Survey Div., Urbana, Ill. (Geology.) (1924.)
Lambert Earl L., B. S., 217 N. 1st St., Carthage, Ill. (Botany and Zoology.) (1917.)
Land, W. J. G., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1911.)
Landon, R. E., 4122 N. Keystone Ave., Chicago, Ill. (1926.)
Langford, George, B. S., McKenna Process Co., Joliet, Ill. (Paleontology.) (1908.)
Lanphier, Robert C., Ph. B., Sangamo Electric Co., Springfield, Ill. (Electricity.) (1914.)
Large, J. M., A. B., 105 Mound, Joliet, Ill. (Geography.) (1927.)
Larned, S. J., M. E., 212 W. Washington St., Chicago, Ill. (Physics.) (1926.)
Larson, E. A., B. A., M. S., 115 Cagwin, Joliet, Ill. (Chemistry.) (1927.)
Larson, Karl C., B. A., Augustana College, Rock Island, Ill. (Chemistry.) (1917.)
Lathrop, W. G., Principal Township High School, Johnston City, Ill. (Geology and Geography.) (1922.)
Laufer, D. Berthold, Ph. D., Field Museum, Chicago, Ill. (Archaeology.) (1925.)
Laves, Kurt, Ph. D., University of Chicago, Chicago, Ill. (Astronomy and Mathematics.) (1920.)
Leech, Bert S., Ph. B., A. M., Highland Park, Ill. (Biology.) (1927.)
Leighton, Morris Morgan, Ph. D., Chief, Illinois Geological Survey Division, Urbana, Ill. (Geology.) (1920.)
Leonard, Thos. H., M. D., 509 S. 6th St., Springfield, Ill. (Medicine.) (1925.)
Lessman, Lem. L., 412 N. Monroe, Peoria, Ill. (1926.)
Lewis, Howard B., Ph. D., University of Michigan, Medical School, Ann Arbor, Michigan (Physiology, Chemistry.) (1920.)
Lewis, Julian H., D. D., Ricketts Laboratory, University of Chicago, Chicago, Ill. (Pathology.) (1921.)
Lichty, Daniel, M. D., Harlem Blvd., Rockford, Ill. (Collateral Anthropology.) (1926.)
Linder, O. A., 208 N. Wells St., Chicago, Ill. (1910.)
Link, T. A., Geology Department, Imperial Oil, Ltd., Calgary, Alberta, Canada. (Geology.) (1926.)
Linkins, R. H., M. A., 706 Broadway, Normal, Ill. (Zoology.) (1917.)
Loach, R. J. H., A. M., 5541 Dorchester Ave., Chicago, Ill. (Biology.) (1927.)
Lockie, G. D., M. D., Springfield, Ill. (Archeology.) (1927.)
Lodge, Fred S., B. S., 423 S. Stone Ave., LaGrange, Ill. (Zoology, Agriculture, Chemistry.) (1926.)
Logan, C. C., B. S., So. Ill. Normal University, Carbondale, Ill. (Agriculture.) (1926.)
Logan, Hay, A. B., 1220 S. Grand Ave., Springfield, Ill. (Mathematics.) (1927.)
Logsdon, Mrs. M. I., Ph. D., University of Chicago, Chicago, Ill. (Mathematics.) (1923.)
Longbons, Elizabeth, B. S., 2 E. Walnut, Harrisburg, Ill. (Chemistry.) (1925.)
Longden, A. C., Ph. D., Knox College, Galesburg, Ill. (Physics.) (1917.)
Lukens, Herman T., Ph. D., 330 Webster Ave., Chicago, Ill. (Geography.) (1920.)
Lutes, Neil, 1395 Atlantic St., Dubuque, Iowa. (Chemistry.) (1912.)
Lyon, William I., 124 Washington, Waukegan, Ill. (Ornithology.) (1926.)
Mac Dowell, Charles H., D. Sc., 111 W. Jackson Blvd., Chicago, Ill. (Chemistry.) (1926.)
Mackie, Arthur D., 400 E. Monroe St., Springfield, Ill. (Electricity.) (1915.)
MacLeod, J. B., 1046 W. Division St., Chicago, Ill. (Chemistry.) (1927.)
MacMillan, W. D., Ph. D., University of Chicago, Chicago, Ill. (Astronomy.) (1922.)
Madison, Wm. D., M. D., Eureka, Ill. (Medicine.) (1921.)
Magill, Henry P., 175 W. Jackson Blvd., Chicago, Ill. (Geology, Sociology, Finance.) (1920.)
Main, Helen, B. S., Gladstone Hotel, Chicago, Ill. (Botany.) (1927.)

Malinovsky, A., Washington Iron Works, Los Angeles, Calif. (Chemistry.) (1920.)
Mann, A. L., M. D., 392 E. Chicago St., Elgin, Ill. (Medicine.) (1921.)
Mann, Jessie R., B. S., State Teachers College, DeKalb, Ill. (Biology.) (1923.)
Marks, Sarah, Pecatonica, Ill. (Biology.) (1917.)
Markus, H. C., Vienna, Ill. (Geology.) (1926.)
Martin, George W., Ph. D., Washington and Jefferson College, Washington, Penn. (Biology.) (1923.)
Marvel, Carl S., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.) (1927.)
Mason, Arthur J., 5715 Woodlawn Ave., Chicago, Ill. (1921.)
Mason, Carol Y., M. A., 1201 W. Oregon St., Urbana, Ill. (Geography, Botany.) (1926.)
Maynard, M. M., A. B., A. M., 734 E. Boston, Monmouth, Ill. (Psychology and Education.) (1927.)
McClure, S. M., Box 57, Lebanon, Ill. (1921.)
McCollom, Roy M., 101 Broadway, Normal, Ill. (Geography.) (1923.)
McCoy, Herbert N., Ph. D., 161 E. Grand Blvd., Chicago, Ill. (Chemistry.) (1914.)
McCulloch, E. C., D. V. M., 8 Bungalow St., Champaign, Ill. (Parasitology.) (1927.)
McDavitt, Neva, 303 North St., Normal, Ill. (Geography.) (1925.)
McDougall, W. B., Ph. D., University of Illinois, Urbana, Ill. (Botany.) (1916.)
McEvoy, S. Aleta, B. S., Rockford High School, Rockford, Ill. (Chemistry.) (1923.)
McGinnis, Helen A., 6400 S. Maplewood Ave., Chicago, Ill. (General Science.) (1923.)
McKee, W. A., D. D. S., East Side Square, Benton, Ill. (1922.)
McMaster, Archie J., 102 W. Iowa St., Urbana, Ill. (Physics and Chemistry.) (1922.)
McShane, John J., 811 S. State St., Springfield, Ill. (Medicine.) (1925.)
Mecham, John B., Ph. D., 118 S. Center St., Joliet, Ill. (1917.)
Metcalf, C. L., Ph. D., Nat. Hist. Bldg., University of Illinois, Urbana, Ill. (Entomology.) (1925.)
Metzner, Albertine E., M. S., 24 Marshner St., Plymouth, Wis. (Geology, Physics.) (1918.)
*Michelson, A. A., LL. D., University of Chicago, Chicago, Ill. (Physics.) (1908.)
Miller, Isiah Leslie, M. A., College Station, Box 53, Brookings, So. Dakota. (Mathematics and Chemistry.) (1920.)
Miller, P. H., High School, Henning, Ill. (Biology.) (1920.)
Miller, R. B., M. F., 121 Capitol Bldg., Department of Conservation, Springfield, Ill. (Forestry and Ecology.) (1920.)
Mitchell, Catharine, A. B., 144 Fairbank Road, Riverside, Ill. (Botany and Ornithology.) (1925.)
Mohme, Fred S., A. B., 255 Natural Hist. Bldg., Univ. of Ill., Urbana, Ill. (Geography.) (1927.)
Mongerson, Oscar V., B. S., Chenoa, Ill. (Physics.) (1925.)
Montgomery, C. E., M. S., State Teachers College, DeKalb, Ill. (Biology.) (1917.)
Moore, Clarence E., B. A., 901 W. Main St., Urbana, Ill. (Botany.) (1924.)
Moore, Eugenia, 6 Cedar Crest, Normal, Ill. (Chemistry.) (1925.)
Morgan, John J. B., Ph. D., 2133 Ridge Ave., Evanston, Ill. (Psychology.) (1926.)
Morgan, Wm. E., M. D., 1016 Hyde Park Blvd., Chicago, Ill. (Medicine.) (1921.)
Morris, Edward A., M. D., 717 E. Capitol Ave., Springfield, Ill. (1925.)
Moulton, C. Robert, Ph. D., 509 S. Wabash Ave., Chicago, Ill. (Chemistry.) (1926.)
Moulton, F. R., Ph. D., 327 South LaSalle St., Chicago, Ill. (Astronomy.) (1912.)
Mumford, H. W., B. S., University of Illinois, Urbana, Ill. (Agriculture.) (1910.)
Murrah, Frank C., M. D., 105½ N. Park Ave., Herrin, Ill. (Medicine.) (1921.)
Murray, A. N., M. S., 311 W. High, Urbana, Ill. (Geology.) (1926.)
Mylius, L. A., S. B., M. E., 704 Shell Bldg., St. Louis, Mo. (Geology.) (1921.)
Nadler, Walter H., M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.) (1921.)
Nash, Edna L., A. B., 316 Linden Place, DeKalb, Ill. (Geography.) (1927.)
Neave, Sidney Lionel, M. A., 1208 W. Clark, Urbana, Ill. (Chemistry.) (1926.)
Neifert, Ira E., M. S., Knox College, Galesburg, Ill. (Chemistry.) (1917.)
Nelson, C. Z., 534 Hawkingson Ave., Galesburg, Ill. (Botany.) (1917.)
Nelson, Emil A., M. E., 1123 W. Edward St., Springfield, Ill. (Engineering.) (1924.)
Newcomb, Rexford, M. A., University of Illinois, Urbana, Ill. (Engineering Applications.) (1920.)
Newell, M. J., M. A., 2226 Hartzell St., Evanston, Ill. (1920.)
Newman, H. H., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1912.)
Nicholson, F. M., 611 S. Ashland Blvd., Chicago, Ill. (Anatomy.) (1920.)
Noé, Adolf Carl, Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1923.)
Nolten, Nell, High School, Springfield, Ill. (Chemistry.) (1925.)
North, E. M., B. A., 694 Garland Pl., DesPlaines, Ill. (Geology, Astronomy, Pedagogy.) (1921.)
Noyes, Wm. Albert, Jr., D. Sc., University of Chicago, Chicago, Ill. (Chemistry.) (1925.)
Obenchain, Jeanette Brown, M. D., 5817 Blackstone Ave., Chicago, Ill. (Anatomy.) (1921.)
Ogilvy, Robert S., 411 Taylor Ave., Glen Ellyn, Ill. (1921.)
Olson, George A., M. S., 4423 N. LaVergne Ave., Chicago, Ill. (Chemistry.) (1926.)
Osment, Arel, 806 Washington Ave., Johnston City, Ill. (General.) (1921.)
Packard, W. H., Ph. D., Bradley Poly. Institute, Peoria, Ill. (Biology.) (1909.)
Paddock, Walter R., M. D., 904 State St., Lockport, Ill. (Medicine.) (1921.)
Paine, Leland S., A. B., A. M., 918 S. Fell Ave., Normal, Ill. (Geography.) (1927.)
Palmer, Charles Shattuck, Ph. D., 1704 Hinman Ave., Evanston, Ill. (Chemistry.) (1925.)
Parr, Rosalie M., Ph. D., 1107 W. Oregon St., Urbana, Ill. (Chemistry.) (1926.)
*Parr, S. W., M. S., University of Illinois, Urbana, Ill. (Chemistry.) (1908.)
Parson, S. F., State Teachers College, DeKalb, Ill. (Mathematics.) (1922.)
Patterson, Alice J., Illinois State Normal University, Normal, Ill. (Entomology, Nature Study.) (1910.)
Patterson Cecil F., B. S., University of Saskatchewan, Saskatoon, Canada. (Botany.) (1920.)
Patton, Charles L., M. D., 407 S. Seventh St., Springfield, Ill. (Medicine.) (1925.)
Patton, Fred P., M. D., Glencoe, Ill. (Medicine.) (1921.)
Paul, Edna, 714 W. California St., Urbana, Ill. (Botany.) (1925.)
Peacock, C. Sheller, LL. B., 323 North 3rd, Monmouth, Ill. (Mycology.) (1925.)

Pearsons, H. P., 1816 Chicago Ave., Evanston, Ill. (1921.)
Penney, Mark Embury, Ph. D., S. T. B., 1441 W. Macon St., Decatur, Ill. (Psychology.) (1926.)
Petersen, C. Beecher, 706 Second Ave., Joliet, Ill. (Geography.) (1927.)
Peterson, Harvey A., 502 Normal Ave., Normal, Ill. (1923.)
Phelps, Lillian B., Golconda, Ill. (Physics.) (1926.)
Phelps, Walter S., D. D. S., 57 Public Sq., Monmouth, Ill. (Mycology.) (1925.)
Phipps, Charles Frank, M. S., 4354 E. Fourth St., Long Beach, Calif. (Physics and Chemistry.) (1917.)
Pieper, Chas. J., University of Chicago, Chicago, Ill. (General Science.) (1921.)
Pianstiehl, Carl, Wood Path Ave., Highland Park, Ill. (Physics and Chemistry.) (1926.)
Piapp, P. W., 4140 N. Keeler Ave., Chicago, Ill. (Botany, Geology.) (1922.)
Platt, Robert S., Ph. D., University of Chicago, Chicago, Ill. (Geography.) (1921.)
Plummer, Beulah A., B. S., Lowell, Ind. (Physiology and Zoology.) (1925.)
Plummer, F. B., 3100 Wabash Ave., Fort Worth, Texas. (Geology.) (1926.)
Plummer, Mrs. Helen J., 3100 Wabash, Fort Worth, Texas. (Geology.) (1926.)
Plunkett, O. A., Ph. D., University of California, Los Angeles, Calif. (Botany.) (1925.)
Poling, J. A., M. D., Henny Bldg., Freeport, Ill. (Medicine.) (1921.)
Pollock, M. D., M. D., Powers Bldg., Decatur, Ill. (Medicine & Surgery.) (1920.)
Poor, R. S., B. S., Ph. D., Birmingham College, Birmingham, Ala. (Geology.) (1925.)
Porter, Charley L., B. S., 484 Northwestern Ave., Lafayette, Ind. (Botany, Plant Pathology.) (1921.)
Quirke, T. T., Ph. D., 234 Nat. Hist. Bldg., University of Illinois, Urbana, Ill. (Geology.) (1921.)
Radcliffe, H. H., 1345 W. Macon St., Decatur, Ill. (Physics, Chemistry.) (1909.)
Ransom, James H., B. S., James Millikin University, Decatur, Ill. (Chemistry.) (1923.)
Ranne, Geo. C., A. M., 405 S. Eastern Ave., Joliet, Ill. (Physics & Chem.) (1927.)
Rauth, Andy Fred, McCormick Theological Seminary, 2330 N. Halsted St., Chicago, Ill. (Biology.) (1924.)
Rea, Helen E., 5904 Midway Park, Chicago, Ill. (Chemistry.) (1927.)
Reagan, Albert B., A. B., A. M., Cornfields, Arizona. (Paleontology.) (1921.)
Redfield, Casper L., 901 Monadnock Block, Chicago, Ill. (Evolution.) (1921.)
Renich, Mary E., Ph. D., Biol. Dept., Alma College, Alma, Mich. (Botany.) (1921.)
Rew, Irwin, A. B., 217 Dempster St., Evanston, Ill. (1920.)
Rice, William F., A. M., Wheaton College, Wheaton, Ill. (Physics.) (1909.)
Richardson, Baxter K., A. B., Dept. of Public Health, Springfield, Ill. (Public Health.) (1921.)
Richardson, R. E., A. M., Box 715, Station A., Champaign, Ill. (Zoology.) (1910.)
Ridgeway, Robert, M. S., 1030 S. Morgan St., Olney, Ill. (Ornithology.) (1917.)
Rinker, Jacob Arron, B. S., Eureka, Ill. (Physics.) (1923.)
Rinker, M. M., B. S., 328 Richland St., Olney, Ill. (Physics.) (1926.)
Roberts, Elmer, B. S., Ph. D., 508 W. Iowa St., Urbana, Ill. (Genetics.) (1927.)
Robinson, Ray R., M. H., 510 Grant Ave., Joliet, Ill. (Geology.) (1927.)
Romer, A. S., Ph. D., University of Chicago, Chicago, Ill. (Paleontology.) (1925.)
Root, Clarence J., U. S. Weather Bureau, Springfield, Ill. (Climatology.) (1913.)
Rose, William C., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.) (1924.)
Royce, Bertha M., B. A., M. A., 204 N. School, Normal, Ill. (Zoology.) (1927.)
Rudisill, Hillyer, Jr., M. D., North Shore Road, Norfolk, Virginia. (Anatomy.) (1927.)
Rudnick, Paul, 10407 S. Leavitt St., Chicago, Ill. (Chemistry.) (1920.)
Sakemiller, Vera M., B. E., 1007 S. Low, Bloomington, Ill. (Biology.) (1927.)
Salter, Allen, M. D., Lena, Ill. (Medicine.) (1920.)
Salzberg, Paul, 375 E. Losy St., Galesburg, Ill. (Chemistry.) (1925.)
Sampson, H. C., Ph. D., Ohio State University, Columbus, Ohio. (1912.)
Savage, Margaret, 613 W. Nevada St., Urbana, Ill. (Botany.) (1925.)
Savage, T. E., Ph. D., University of Illinois, Urbana, Ill. (Stratigraphic Geology.) (1908.)
Schantz, Orpheus M., Room 521, 137 S. LaSalle St., Chicago, Ill. (Birds, Plants.) (1920.)
Schaub, Edward L., Ph. D., 629 Garrett Place, Evanston, Ill. (Psychology.) (1920.)
Schmidt, Otto L., M. D., 5 So. Wabash Ave., Chicago, Ill. (History.) (1921.)
Schmoll, Hazel Marguerite, B. E., M. S., Ward, Colo. (Botany.) (1921.)
Schrepfer, Frank A., A. B., University of Pennsylvania, Philadelphia, Pa. (Botany.) (1925.)
Schulz, W. F., Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1910.)
Schwartzberg, Benj., 1317 So. Homan Ave., Chicago, Ill. (Bacteriology.) (1926.)
Scott, Harold U., 514 E. Detroit Ave., Monmouth, Ill. (Mycology.) (1925.)
Sears, O. H., 606 E. Chalmers St., Champaign, Ill. (Chemistry.) (1922.)
Sellin, Hilding, A. B., Snell Hall, No. 43, University of Chicago, Chicago. (Geology.) (1927.)
Shamel, C. H., Ph. D., Taylorville, Ill. (Chemistry.) (1916.)
Shank, Marjorie M., A. M., 718 S. Normal, Carbondale, Ill. (Geography.) (1924.)
Shantz, H. L., Ph. D., D. Sc., Univ. of Ill., Urbana, Ill. (Botany.) (1927.)
Shelford, V. E., Ph. D., Vivarium Bldg., Wright and Healy Sts., Champaign, Ill. (Zoology, Ecology.) (1908.)
Sheretz, D. Ransom, Ed. B., 515 E. Clay, Collinsville, Ill. (Zoology.) (1925.)
Shull, Chas. A., Ph. D., University of Chicago, Chicago, Ill. (Botany, Plant Physiology.) (1924.)
Siedenberg, Frederick, M. A., Lyola College, Rogers Park, Chicago, Ill. (Sociology.) (1920.)
Simmons, Marguerite L., B. S., M. A., 325 Melrose Ave., Centralia, Ill. (Biology.) (1921.)
Simonds, O. C., 1101 Buena Ave., Chicago, Ill. (Botany.) (1920.)
Simons, Etoile B., Ph. D., 7539 Colfax Ave., Chicago, Ill.) (Botany.) (1920.)
Singer, H. Douglas, M. D., 25 E. Washington St., Chicago, Ill. (Psychiatry.) (1920.)
Slocum, A. W., University of Chicago, Chicago, Ill. (1908.)
Slye, Maud, A. B., 5836 Drexel Ave., Chicago, Ill. (1921.)
Smallwood, Mabel E., 550 Surf St., Chicago, Ill. (Zoology.) (1908.)
Smith, Arthur Bessey, B. S., 2324 Hartzell St., Evanston, Ill. (Telephony.) (1920.)
Smith, Arthur L., A. B., Eureka, Ill. (Biology.) (1927.)
Smith, Clarence R., B. S., M. S., Aurora College, Aurora, Ill. (Physics.) (1921.)

Smith, Mrs. Eleanor C., B. S., 104 Winston Ave., Joliet, Ill. (Biology.) (1919.)
Smith, George Hume, Ph. D., Univ. of Penn., Philadelphia, Pa. (Biological Abstracts.) (1921.)
Smith, Grant, M. S., Ph. D., 6107 Woodlawn Ave., Chicago, Ill. (1921.)
Smith, Guy N., B. S., Rockford High School, Rockford, Ill. (Botany.) (1925.)
Smith, Jesse L., Supt. of Schools, Highland Park, Ill. (1908.)
Smith, K. K., Ph. D., 2200 Sherman Ave., Evanston, Ill. (Physics.) (1916.)
Smith, R. S., Ph. D., University of Illinois, Urbana, Ill. (Chemistry and Physics of Soils.) (1920.)
Smith, S. S., Steeleville, Randolph Co., Ill. (Vocational and Physical Education.) (1920.)
Snider, Alvin B., M. D., Blue Island, Ill. (Medicine.) (1921.)
Snider, H. J., B. S., University of Illinois, Urbana, Ill. (Soils, Agri.) (1921.)
Solheim, Wilhelm G., A. B., A. M., Univ. of Ill., Urbana, Ill. (Botany.) (1927.)
Somes, M. P., M. S., 805 Second Ave., Joliet, Ill. (Zoology.) (1927.)
Sonnenschein, Robert, M. D., 4518 Woodlawn Ave., Chicago, Ill. (Medicine.) (1920.)
Spicer, C. E., 100 Sherman St., Joliet, Ill. (Chemistry.) (1908.)
Spooner, Charles S., A. B., A. M., 1436 7th St., Charleston, Ill. (Zoology.) (1920.)
Spoor, H. C., Jr., B. S., 407 W. Washington, Urbana, Ill. (Geology.) (1926.)
Stabin, George W., M. D., First National Bank Bldg., Springfield, Ill. (Medicine.) (1925.)
Stansfield, John, M. A., M. S., 902 West Illinois, Urbana, Ill. (Geology.) (1925.)
Stark, John Thomas, M. A., 749 Sherman Ave., Evanston, Ill. (Geology.) (1925.)
Steagall, Mary M., Ph. D., 808 S. Illinois Ave., Carbondale, Ill. (Botany.) (1921.)
Stein, Hilda Anna, B. Ed., 409 W. Jackson, Carbondale, Ill. (Zoology.) (1926.)
Stevens, F. L., Ph. D., University of Illinois, Urbana, Ill. (Plant Pathology.) (1914.)
Stillians, A. W., M. D., 911 East 50th St., Chicago, Ill. (Medicine.) (1921.)
Stout, Gilbert L., A. B., 204 Vivarium Bldg., Champaign, Ill. (Botany.) (1927.)
Stover, E. L., State Teachers College, Charleston, Ill. (Botany.) (1924.)
Stover, Mrs. E. L., M. S., 930 Second St., Charleston, Ill. (Botany.) (1923.)
*Strode, W. S., M. D., Lynwood, California. (Ornithology.) (1908.)
Strong, Harriet, B. S., 702 Maple Ave., Downers Grove, Ill. (Biology.) (1917.)
Struble, R. H., A. B., 4481 Sheridan Ave., Detroit, Mich. (Physics.) (1921.)
Sturm, Kathryn, Ed. B., 608 S. Main St., Anna, Ill. (Zoology.) (1927.)
Swan, W. S., M. D., Cor. Main and Walnut Sts., Harrisburg, Ill. (Medicine.) (1921.)
Talmage, Sterling B., M. S., Ph. D., 2249 Ridge Ave., Evanston, Ill. (Geology.) (1927.)
Tatum, Arthur L., Ph. D., M. D., University of Chicago, Chicago, Ill. (Physiology, Pharmacology.) (1920.)
Taylor, Harry, Harrisburg, Ill. (1925.)
Taylor, Mildred E., A. B., A. M., Knox College, Galesburg, Ill. (Mathematics.) (1922.)
Tehon, Leo R., A. B., M. A., University of Illinois, Urbana, Ill. (Botany. Plant Pathology.) (1922.)
Terwilliger, George L., B. E., 330 College Ave., DeKalb, Ill. (Biology.) (1926.)
Thoraldsen, C. E., M. A., 719 Emerson St., Evanston, Ill. (Zoology.) (1924.)
Thomas, E. T., M. A., Willow Grove, Tennessee. (Geology.) (1923.)
Thomas, Gertrude M., 1003 N. Court St., Rockford, Ill. (Biology.) (1924.)
Thomas, L. J., Ph. D., 313 Natural History Bldg., University of Illinois, Urbana, Ill. (Zoology.) (1923.)
Thompson, Louis T. E., Ph. D., Naval Proving Station, Dahlgren, Va. (Physics.) (1921.)
Thurlimann, Leota, 4054 Washington Blvd., Chicago, Ill. (Botany.) (1921.)
Thurston, Fredus A., 1361 E. 57th St., Chicago, Ill. (1921.)
Tiffany, L. Hanford, Ohio State Univ., Columbus, Ohio. (Botany.) (1914.)
Toler, H. N., B. S., Care of The Texas Company, 17 Battery Place, New York, N. Y. (Geology.) (1926.)
Townsend, M. T., B. S., St. John's College, Annapolis, Md. (Animal Ecology.) (1921.)
Townsley, Fred D., B. A., James Millikin University, Decatur, Ill. (1916.)
Trapp, A. R., M. D., Illinois National Bank Bldg., Springfield, Ill. (Medical Diagnosis.) (1914.)
Turner, Lewis M., B. S., Blackburn College, Carlinville, Ill. (Botany.) (1925.)
Turton, Chas. M., M. A., 2055 E. 72nd Place, Chicago, Ill. (Physics.) (1908.)
Tuttle, H. H., M. D., Illinois Bank Bldg., Springfield, Ill. (Medicine.) (1925.)
Ulrich, Katherine, Ph. B., 1006 No. Boul., Oak Park, Ill. (Geology, Geography, Botany.) (1921.)
Underhill, Editha, M. S., Rockford College, Rockford, Ill. (Chemistry.) (1926.)
Utzig, Esther W., A. B., 507 N. Major Ave., Chicago, Ill. (Geography.) (1925.)
Vance, Charles, Rantoul, Ill. (Physics.) (1926.)
Van Cleave, H. J., Ph. D., University of Illinois, Urbana, Ill. (Zoology.) (1910.)
Van Hooser, B., A. B., M. D., 25 E. Washington St., Chicago, Ill. (Medicine) (1927.)
Van Tuyle, Francis M., Ph. D., Colorado School of Mines, Golden, Colo. (Geology) (1916.)
Vestal, A. G., Ph. D., Biology Laboratory, Stanford University, Calif. (Ecology.) (1910.)
Vogel, Alfred C., B. S., M. S., Botany Department, Ohio State University, Columbus, Ohio. (Botany.) (1927.)
Waldo, Jennie E., 1204 Third Ave., Rockford, Ill. (Biology.) (1922.)
Walker, Ellis David, M. D., B. Sc., 5519 University Ave., Chicago, Ill. (Pedagogical Med., Biol., Agri.) (1921.)
Walsh, John, Box 212, Galesburg, Ill. (Water Supply.) (1921.)
Wanless, Harold R., Ph. D., 1114 W. Nevada, Urbana, Ill. (Geology.) (1924.)
Warbrick, John C., M. D., M. C., 306 E. 43rd St., Chicago, Ill. (Birds, Nature Study.) (1920.)
Ward, Harold B., B. S., Northwestern Univ., Evanston, Ill. (Geology, Geography.) (1910.)
Warner, Glen W., A. B., A. M., 7633 Calumet Ave., Chicago, Ill. (Physics.) (1927.)
Waterman, Warren G., Ph. D., Northwestern University, Evanston, Ill. (Botany.) (1914.)
Watson, F. R., Ph. D., Dept. of Physics, University of Illinois, Urbana, Ill. (1909.)
Watson, Josiah S., B. S., M. S., Ind. & Adella, Joliet, Ill. (Zoology, Botany.) (1927.)
Waugh, Anna, A. B., 6620 Yale Ave., Chicago, Ill. (Botany.) (1927.)
Weaver, George H., M. D., 629 S. Wood St., Chicago, Ill. (Medicine, Bacteriology.) (1920.)
Weber, H. C. P., Ph. D., Westinghouse Electric Co., Pittsburgh, Pa. (Chemistry.) (1914.)

Weckel, Ada L., M. S., Twp. High School, Oak Park, Ill. (Zoology.) (1917.)
Weese, Asa Orrin, Ph. D., University of Oklahoma, Norman, Oklahoma. (1924.)
Weir, Mary E., Ph.B., Carbondale, Ill. (Geography.) (1927.)
Weichelt, A., M. D., Barrington, Ill. (Medicine.) (1921.)
Weld, Lewis H., U. S. Natl. Museum, Washington, D. C. (Entomology.) (1927.)
Welker, William H., Ph. D., Univ. of Illinois College of Medicine, 1817 W. Polk St., Chicago) Ill. (Biological Chemistry.) (1920.)
Weller, J. Marvin, University of Illinois, Urbana, Ill. (Geological Survey.) (1926.)
Wellman, Murrell, Joliet, Ill. (Physiography.) (1927.)
Wells, M. M., Ph. D., General Biological Supply House, 761-763 East 69th Place, Chicago, Ill. (Zoology.) (1913.)
Wentworth, Edward N., B. S., M. S., Armour's Bureau of Agricultural Research and Economics, Chicago, Ill. (Genetics and Economics.) (1922.)
White, Mrs. Florence, B. A., 119 Dement, Dixon, Ill. (Biology.) (1927.)
White, J. Kay, Milledgeville, Ill. (Geology.) (1926.)
Whitmore, Frank C., Ph. D., Northwestern University, Evanston, Ill. (Organic Chemistry.) (1921.)
Whitney, Worallo, A. M., 5743 Dorchester Ave., Chicago, Ill. (Botany.) (1910.)
Whitten, J. H., Ph. D., 7111 Normal Blvd., Chicago, Ill. (Botany.) (1917.)
Wicks, Nina H., B. S., M. S., 218 Iowa, Joliet, Ill. (Zoology.) (1927.)
Wickwire, Geo. C., B. S., M. S., Univ. of Ill., Urbana, Ill. (Physiology.) (1927.)
Williams, E. G. C., M. D., 316 The Temple, Danville, Ill. (Medicine, Clinical Pathology.) (1920.)
Williams, E. H., Ph.D., 804 Michigan Ave., Urbana, Ill. (Physics.) (1925.)
Williams, Pauline, B. S., 226 S. 19th St., Murphysboro, Ill. (Biology.) (1926.)
Willier, Benj. H., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1921.)
Willman, H. B., 705 S. Goodwin St., Urbana, Ill. (Geology.) (1925.)
Wilson, J. Gordon, M. D., 5755 Kenwood Ave., Chicago, Ill. (Otology.) (1921.)
Windsor, Mrs. P. L., 701 Michigan Ave., Urbana, Ill. (Entomology.) (1913.)
Winstrom, Harry J., A. B., M. A., Supt. of Schools, Springfield, Ill. (Education.) (1925.)
*Winter, S. G., M. A., Lombard College, Galesburg, Ill. (Histology.) (1908.)
Witt, J. C., Ph. D., 5834 Stony Island Ave., Chicago, Ill. (Chemistry.) (1923.)
Witzemann, Edgar J., Ph. D., Science Hall, University of Wisconsin, Madison, Wis. (Chemistry.) (1920.)
Wolkoff, M. I., Ph. D., 226 E. 56th St., Chicago, Ill. (Soil Fertility.) (1922.)
*Wood, F. E., A. B., 804 N. Evans St., Bloomington, Ill. (Biology.) (1908.)
Woods, P. C., 100 N. Cherry St., Galesburg, Ill. (Physics.) (1917.)
Workman, L. E., M. S., Asst. Geologist, State Geological Survey, Urbana, Ill. (Geology.) (1926.)
Worsham, Walter B., A. B., 403 W. Monroe St., Springfield, Ill. (Physics.) (1924.)
Wright, Mrs. Maurie Bailey, A. B., A. M., 403 Penn. St., Rockville, Ind. (Botany.) (1927.)
Wright, Frank, M. D., 5 S. Wabash Ave., Chicago, Ill. (Biological Chemistry.) (1920.)
Wright, Paul R., B. A., Michigan Ave. and Oak St., Highland Park, Ill. (Geology.) (1924.)
Wynne, Ross B., A. B., 7335 Kenwood Ave., Chicago, Ill. (Botany.) (1920.)
Yoggy, I. D., B. S., 116 Bartleson St., Joliet, Ill. (Physics.) (1927.)
Young, Mrs. J. D., M. S., Windermere Hotel, 56th St. and Cornell Ave., Chicago, Ill. (Zoology.) (1911.)
*Zetek, James, A. M., Box 245, Ancon, Panama Canal Zone. (Entomology.) (1908.)
Zimmerman, Augus G., 30 N. Michigan Ave., Chicago, Ill. (Biology Science.) (1920.)
Zimmerschied, Charlotte, B. A., M. A., 808 S. Illinois Ave., Carbondale, Ill. (Physics.) (1926.)
Zoller, C. H., M. D., Hughes Bldg., Litchfield, Ill. (Medicine.) (1921.)

SCIENTIFIC SOCIETIES AFFILIATED WITH THE ACADEMY.

Burrill Botany Club, 204 Natural History Bldg., University of Illinois, Urbana, Ill. (1925.)
Englewood Biology Club, Englewood, Illinois. (1925.)
Illinois Nature Study Society of Elgin, 310 N. Liberty St., Elgin, Ill. (1924.)
Joliet Botanical Club, Florence Martin, Secy. Joliet, Ill. (1925.)
Knox County Academy of Science, Galesburg, Ill. Fred R. Jelliff, President. (1923.)
Normal Science Club, Illinois State Normal University, Normal, Ill. (1923.)
Rockford Nature Study Society, Florence P. Davey, Secy. and Treas. Rockford, Ill. (1923.)
Science Club, State Normal University, Carbondale, Ill. (1925.)
Sigma Xi, University of Chicago Chapter, Chicago, Ill. (1925.)
Sigma Xi, University of Illinois Chapter, Urbana, Ill. (1925.)
The Botany Club of Joliet, c/o H. V. Givens, Midland Ave., Joliet, Ill. (1925.)
The Chicago Academy of Science, Dr. J. C. Cowles, University of Chicago. Chicago, Ill. (1925.)

HIGH SCHOOL SCIENCE CLUBS.

Assisi Junior College, Joliet, Ill. (1927.)
Boys' Science Club, High School, Galesburg, Ill. (1923.)
Chicago Nature Study Club, c/o Dr. H. S. Pepoon, 3842 Byron St., Chicago, Ill.
Danville Science Club, High School, Danville, Ill. (1923.)
Edisonian Science Club, Henry, Ill. (1926.)
Englewood High School General Science Club, 62nd St. and Stewart Ave., Chicago, Ill. (1924.)
Eureka Science Club, Eureka Township High School, Eureka, Ill. (1923.)

Scientific and Common Names	Number of rows of dorsal scales	Dorsal scales keeled	Shape of the rostral plate	Number of nasals	Pit between eye and nostril	Loreal present	Number of upper labial plates	Number of lower labial
1. *Carphophis amoena helenae* worm-snake	13	0	normal	1	0	+	5	
2. *Farancia abacura* horn-snake	19–21	+	normal	1	0	+	7–8	8
3. *Diadophis punctatus arnyi* ring-neck snake	15–17	0	normal	2	0	+	7	
4. *Diadophis punctatus edwardsii* ring-neck snake	15	0	normal	2	0	+	8	
5. *Diadophis punctatus strictogenys* ring-neck snake	15	0	normal	2	0	+	7	
6. *Heterodon contortrix* spreading adder, puffing adder	23–25	+	plow-shape	2	0	+	8	
7. *Heterodon simus* spreading adder	25–27	+	plow-shape	2	0	+	8	
8. *Liopeltis vernalis* smooth green-snake	15	0	normal	1	0	+	7	
9. *Opheodrys aestivus* rough green-snake	17	+	normal	1	0	+	7	
10. *Coluber constrictor constrictor* black-snake	15–17	0	normal	2	0	+	7	
11. *Coluber constrictor flaviventris* blue racer	15–17	0	normal	2	0	+	7	
12. *Elaphe guttata* corn-snake	25–27	0–5	normal	2	0	+	8	
13. *Elaphe obsoleta obsoleta* pilot black-snake	25–29	17	normal	2	0	+	8	
14. *Elaphe vulpina* fox-snake	25–33	9	normal	2	0	+	8	
15. *Pituophis sayi* bull-snake	31–35	+	normal	2	0	+	8	
16. *Lampropeltis calligaster* yellow bellied king-snake	25–27	0	wedged	2	0	+	7	
17. *Lampropeltis getulus holbrooki* speckled king-snake	21	0	normal	2	0	+	7	
18. *Lampropeltis getulus nigra* black king-snake	21	0	normal	2	0	+	7	9(
19. *Lampropeltis triangulum triangulum* milk-snake	17–21	0	normal	2	0	+	7	
20. *Lampropeltis triangulum syspila* red milk-snake	17–21	0	normal	2	0	+	7	
21. *Natrix cyclopion*	27–33	+	normal	1	0	+	8	
22. *Natrix grahamii* Graham's water-snake	19–20	+	normal	1	0	+	7–8	
23. *Natrix kirklandii* Kirkland's water snake	19	+	normal	1	0	+	6	
24. *Natrix rhombifera* water-snake	27 (25–31)	+	normal	1	0	+	8	1
25. *Natrix septemvittata* striped water-snake	19	+	normal	1	0	+	7–8	
26. *Natrix sipedon sipedon* water-snake	23	+	normal	1	0	+	7	
27. *Natrix sipedon erythrogaster* copper belly	23–25	+	normal	1	0	+	7	
28. *Storeria dekayi* deKay's snake	17	+	normal	2	0	0	7	
29. *Storeria occipitomaculata* red-bellied snake	15	+	normal	2	0	0	6–7	
30. *Virginia valeriae elegans*	17	+	normal	2	0	+	6	
31. *Potamophis striatulus* ground snake	17	+	normal	2	0	+	5	
32. *Tropidoclonium lineatum* striped swamp snake	17–19	+	normal	1	0	+	6–7	
33. *Thamnophis radix radix* garter snake	17–21	+	normal	2	0	+	7–8	

TABLE II.

ACTERS AVAILABLE FOR THE RECOGNITION OF THE SNAKES OF ILLINOIS*

	Number of lower labial plates	Number of preocular scales	Number of postocular scales	Number of subocular scales	Is the anal plate divided	Number of ventral scutes	Number of subcaudal scutes	Are rattles present?	Di Dorsal Surfac
5	6	0	1	2–3	+	120–125	30–36	0	uniformly olive brown
8	8–10	0	2	0	+	172–196	35–49	0	uniformly bluish black
7	7	2	2	0	+	145–193+	36–59	0	black or dark brown; ye band
8	7	2	2	0	+	149–152	51±	0	dark gray with bright ye ring
7	7	2	2	0	+	150–	?	0	light brownish olive; ye band
8	9	3–4	3–4	3	+	124–148	46–58	0	20–31 light median brown; lateral spots s
8	9	3	3	3	+	146±	40±	0	about 35 dorsal blotche 3 lateral rows
7	8	1–2	2	0	+	131–139	69–94	0	uniform pale green
7	8–7	1–2	2	0	+	150–170	111–134	0	uniformly pale green
7	8	2	2	0	+	173–179±	83–92±	0	solid blue-black, young
7	9	2	2	0	+	172–190	89–110	0	uniformly greenish blue
8	11	1	2	0	+	200–235	65–79	0	27-40 reddish dorsal blot
8	13	1	2–3	0	+	231–239	76–85	0	uniform black or gray w blotches
8	10	1	2	0	+	194–211	.....	0	31–38 dorsal blotches brown
8	11–13	1–2	2–5	.....	0	209–228	51–60	0	40–60 square dark dorsa on yellow
7	9–10	1	2	0	0	199–207	43–47	0	46–78 dorsal blotches and post. margins cond
7	7–10	1	2	0	0	200–224	41–52	0	yellow spot on each dorsa
7	9(8–10)	1	2	0	0	199–216	41–53	0	chiefly black; 50-90 ver yellow cross lines
7	9	1	2	0	0	180–213	29–54	0	35–60 dorsal saddles
7	9	1	2	0	0	180–215	43–54	0	23–35 dorsal saddles
8	10–12	1	2	2–3	+	±144	±65	0	brown obscurely mark black
-8	10	2	2	0	+	156–173	54–65	0	brown with median an pale stripes
6	7	1	2	0	+	131–133	52–65	0	brown with black spots,
8	10–11	1	2–3	0	+	130–150	40–80	0	26–33 dorsal spots on bro
-8	9–10	2	2	0	+	140–149	64–81	0	brown; median scales an with dark stripe; ligh stripe
7	10	1	3	0	+	135–155	40–80	0	lateral spots not alt. wi as far forward as head
7	10	1	3	0	+	145–155	64–85	0	uniform dark or reddish
7	7	1	1–2	0	+	120–128	48–60	0	grayish and chestnut w median stripe and late
-7	7	2	2	0	+	117–128	43–52	0	olive to chestnut; 3 pale spots
6	6	0	2±	0	+	120–125	25	0	uniform bluish black
5	6	0	1	0	+	119–130	25–46	0	grayish or reddish brow nut parietal band
-7	5–7	1	2	0	0	138–150	26	0	grayish brown; light m stripe
-8	8	1	3	0	0	150–160	65–75	0	median and lateral str rows 3+4); black

TABLE II.

A Tabulation of the Characters Available for the Recognition of the Sp

Dorsal scales keeled	Shape of the rostral plate	Number of nasals	Pit between eye and nostril	Loreal present	Number of upper labial plates	Number of lower labial plates	Number of preocular scales	Number of postocular scales	Number of subocular scales	Is the anal plate divided	Number of ventral scutes	
0	normal	1	0	+	5	6	0	1	2–3	+	120–125	
+	normal	1	0	+	7–8	8–10	0	2	0	+	172–196	
0	normal	2	0	+	7	7	2	2	0	+	145–193+	
0	normal	2	0	+	8	7	2	2	0	+	149–152	
0	normal	2	0	+	7	7	2	2	0	+	150–	
+	plow-shape	2	0	+	8	9	3–4	3–4	3	+	124–148	
+	plow-shape	2	0	+	8	9	3	3	3	+	146±	
0	normal	1	0	+	7	8	1–2	2	0	+	131–139	
+	normal	1	0	+	7	8–7	1–2	2	0	+	150–170	11
0	normal	2	0	+	7	8	2	2	0	+	173–179±	
0	normal	2	0	+	7	9	2	2	0	+	172–190	8
0–5	normal	2	0	+	8	11	1	2	0	+	200–235	
17	normal	2	0	+	8	13	1	2–3	0	+	231–239	
9	normal	2	0	+	8	10	1	2	0	+	194–211	
+	normal	2	0	+	8	11–13	1–2	2–5	.....	0	209–228	
0	wedged	2	0	+	7	9–10	1	2	0	0	199–207	
0	normal	2	0	+	7	7–10	1	2	0	0	200–224	
0	normal	2	0	+	7	9(8–10)	1	2	0	0	199–216	
0	normal	2	0	+	7	9	1	2	0	0	180–213	
0	normal	2	0	+	7	9	1	2	0	0	180–215	
+	normal	1	0	+	8	10–12	1	2	2–3	+	±144	
+	normal	1	0	+	7–8	10	2	2	0	+	156–173	
+	normal	1	0	+	6	7	1	2	0	+	131–133	
+	normal	1	0	+	8	10–11	1	2–3	0	+	130–150	
+	normal	1	0	+	7–8	9–10	2	2	0	+	140–149	
+	normal	1	0	+	7	10	1	3	0	+	135–155	
+	normal	1	0	+	7	10	1	3	0	+	145–155	
+	normal	2	0	0	7	7	1	1–2	0	+	120–128	
+	normal	2	0	0	6–7	7	2	2	0	+	117–128	
+	normal	2	0	+	6	6	0	2±	0	+	120–125	
+	normal	2	0	+	8	6	0	1	0	+	119–130	
+	normal	1	0	+	6–7	5–7	1	2	0	0	138–150	
+	normal	2	0	+	7–8	8	1	3	0	0	150–160	

	Number of subcaudal scutes	Are rattles present?	Distinctive Color Markings	
			Dorsal Surface	Ventral Surface
	30–36	0	uniformly olive brown	flesh color
	35–49	0	uniformly bluish black	brick red with black cross bands
+-	36–59	0	black or dark brown; yellow neck band	yellowish with brown or black spots
2	51+	0	dark gray with bright yellow neck ring	immaculate or spots in a single median row
	?	0	light brownish olive; yellow neck band	spots in single median row or irregular
3	46–58	0	20–31 light median spots on brown; lateral spots smaller	light in old, dark in young
	40+	0	about 35 dorsal blotches and 2 or 3 lateral rows	yellowish more or less blotched with black
9	69–94	0	uniform pale green	greenish white
0	111–134	0	uniformly pale green	greenish white
9+	83–92+	0	solid blue-black, young with spots	white to slate
0	89–110	0	uniformly greenish blue	greenish to pale yellow
5	65–79	0	27-40 reddish dorsal blotches	yellowish checked with black
9	76–85	0	uniform black or gray with black blotches	straw with square or elongate black blotches
1	.....	0	31–38 dorsal blotches on light brown	yellow with dark spots
8	51–60	0	40–60 square dark dorsal blotches on yellow	whitish with large black blotches
7	43–47	0	46–78 dorsal blotches with ant. and post. margins concave	checkered or with only ends of ventrals mottled
4	41–52	0	yellow spot on each dorsal scale	yellowish with large dark blotches
6	41–53	0	chiefly black; 50-90 very narrow yellow cross lines	gray with white spots
3	29–54	0	35–60 dorsal saddles	checkered black and white or suffused with red
5	43–54	0	23–35 dorsal saddles	checkered with square blotches
4	+65	0	brown obscurely marked with black	yellow to brown with black dot on each scute
3	54–65	0	brown with median and lateral pale stripes	yellowish with median stripe
3	52–65	0	brown with black spots, no stripes	brick red
0	40–80	0	26–33 dorsal spots on brown	blotched with black
9	64–81	0	brown; median scales and 5th row with dark stripe; light lateral stripe	yellow with two longitudinal stripes of brown
5	40–80	0	lateral spots not alt. with dorsal as far forward as head	numerous black edged half circles
5	64–85	0	uniform dark or reddish brown	uniform light or reddish, some with dark markings
8	48–60	0	grayish and chestnut with light median stripe and lateral spots	pinkish white
8	43–52	0	olive to chestnut; 3 pale occipital spots	reddish, without spots
5	25	0	uniform bluish black	yellowish white
0	25–46	0	grayish or reddish brown, chestnut parietal band	yellowish or reddish brown
0	26	0	grayish brown; light mid-dorsal stripe	transverse black spot on each plate
0	65–75	0	median and lateral stripes (on rows 3+4); black spots be-	greenish, black spots near edges

5. *Diadophis punctatus stictogenys* ring-neck snake	15	0	normal	2	0	+	
6. *Heterodon contortrix* spreading adder, puffing adder	23–25	+	plow-shape	2	0	+	
7. *Heterodon simus* spreading adder	25–27	+	plow-shape	2	0	+	
8. *Liopeltis vernalis* smooth green-snake	15	0	normal	1	0	+	
9. *Opheodrys aestivus* rough green-snake	17	+	normal	1	0	+	
10. *Coluber constrictor constrictor* black-snake	15–17	0	normal	2	0	+	
11. *Coluber constrictor flaviventris* blue racer	15–17	0	normal	2	0	+	
12. *Elaphe guttata* corn-snake	25–27	0–5	normal	2	0	+	
13. *Elaphe obsolrta obsoleta* pilot black-snake	25–29	17	normal	2	0	+	
14. *Elaphe vulpina* fox-snake	25–33	9	normal	2	0	+	
15. *Pituophis sayi* bull-snake	31–35	+	normal	2	0	+	
16. *Lampropeltis calligaster* yellow bellied king-snake	25–27	0	wedged	2	0	+	
17. *Lampropeltis getulus holbrooki* speckled king-snake	21	0	normal	2	0	+	
18. *Lampropeltis getulus nigra* black king-snake	21	0	normal	2	0	+	
19. *Lampropeltis triangulum triangulum* milk-snake	17–21	0	normal	2	0	+	
20. *Lampropeltis triangulum syspila* red milk-snake	17–21	0	normal	2	0	+	
21. *Natrix cyclopion*	27–33	+	normal	1	0	+	
22. *Natrix grahamii* Graham's water-snake	19–20	+	normal	1	0	+	7
23. *Natrix kirklandii* Kirkland's water snake	19	+	normal	1	0	+	
24. *Natrix rhombifera* water-snake	27 (25–31)	+	normal	1	0	+	
25. *Natrix septemvittata* striped water-snake	19	+	normal	1	0	+	7
26. *Natrix sipedon sipedon* water -snake	23	+	normal	1	0	+	
27. *Natrix sipedon erythrogaster* copper belly	23–25	+	normal	1	0	+	
28. *Storeria dekayi* deKay's snake	17	+	normal	2	0	0	
29. *Storeria occipitomaculata* red-bellied snake	15	+	normal	2	0	0	6
30. *Virginia valeriae elegans*	17	+	normal	2	0	+	
31. *Potamophis striatulus* ground snake	17	+	normal	2	0	+	
32. *Tropidoclonium lineatum* striped swamp snake	17–19	+	normal	1	0	+	6
33. *Thamnophis radix radix* garter snake	17–21	+	normal	2	0	+	7
34. *Thamnophis sauritus proximus* ribbon snake	19	+	normal	2	0	+	
35. *Thamnophis sauritus sauritus* ribbon snake	19	+	normal	2	0	+	
36. *Thamnophis sirtalis sirtalis* garter snake	17–19	+	normal	2	0	+	
37. *Thamnophis sirtalis parietalis* red-sided garter snake	17–19	+	normal	2	0	+	
38. *Agkistrodon mokasen* copperhead	23	+	large	2	+	+	
39. *Agkistrodon piscivorus* cotton-mouth moccasin	25	+	large	2	+	+	7
40. *Sistrurus catenatus catenatus* massa sauga or prairie rattler	25	+	normal	2	+	+	12
41. *Crotalus horridus* timber rattler	23–25	+	small	2	+	+	

*See foot-note on page 185.

rows 3+4); black spots be-

									ring
7	7	2	2	0	+	150–	?	0	light brownish olive; band
8	9	3-4	3-4	3	+	124–148	46–58	0	20–31 light media brown; lateral spot
8	9	3	3	3	+	146+	40+	0	about 35 dorsal blotc 3 lateral rows
7	8	1–2	2	0	+	131–139	69–94	0	uniform pale green
7	8–7	1–2	2	0	+	150–170	111–134	0	uniformly pale green
7	8	2	2	0	+	173–179±	83–92±	0	solid blue-black, youn
7	9	2	2	0	+	172–190	89–110	0	uniformly greenish b
8	11	1	2	0	+	200–235	65–79	0	27-40 reddish dorsal b
8	13	1	2–3	0	+	231–239	76–85	0	uniform black or gra blotches
8	10	1	2	0	+	194–211	.....	0	31–38 dorsal blotch brown
8	11–13	1–2	2–5	.....	0	209–228	51–60	0	40–60 square dark do on yellow
7	9–10	1	2	0	0	199–207	43–47	0	46–78 dorsal blotch and post. margins
7	7–10	1	2	0	0	200–224	41–52	0	yellow spot on each d
7	9(8–10)	1	2	0	0	199–216	41–53	0	chiefly black; 50-90 yellow cross lines
7	9	1	2	0	0	180–213	29–54	0	35–60 dorsal saddles
7	9	1	2	0	0	180–215	43–54	0	23–35 dorsal saddles
8	10–12	1	2	2–3	+	±144	+65	0	brown obscurely m black
7–8	10	2	2	0	+	156–173	54–65	0	brown with median pale stripes
6	7	1	2	0	+	131–133	52–65	0	brown with black spo
8	10–11	1	2–3	0	+	130–150	40–80	0	26–33 dorsal spots on
7–8	9–10	2	2	0	+	140–149	64–81	0	brown; median scales with dark stripe; stripe
7	10	1	3	0	+	135–155	40–80	0	lateral spots not alt as far forward as h
7	10	1	3	0	+	145–155	64–85	0	uniform dark or redd
7	7	1	1–2	0	+	120–128	48–60	0	grayish and chestnu median stripe and
6–7	7	2	2	0	+	117–128	43–52	0	olive to chestnut; 3 spots
6	6	0	2±	0	+	120–125	25	0	uniform bluish black
5	6	0	1	0	+	119–130	25–46	0	grayish or reddish b nut parietal band
6–7	5–7	1	2	0	0	138–150	26	0	grayish brown; ligh stripe
7–8	8	1	3	0	0	150–160	65–75	0	median and lateral rows 3+4); bla tween stripes
8	8	1	3	0	0	170–180	100–108	0	dark brown or black and lateral strip 3+4)
7	8	1	3	0	0	±157	115–118	0	light brown with y median and on ro
7	8	1	3	0	0	140–170	60–80	0	olive brown to dar green median and (on rows 2+3)
7	10	1	3	0	0	146–170	66–95	0	stripes on rows 2+3; dark spots, orange
8	10	3	4–6	2–3	0	±150	±45	0	light brown; invert brown marks on e
7–8	10	3	3	0	0	±136	±45	0	brown or blackish w transverse black b
12–13	12–13	2	4	4	0	137–143	28	+	gray to blackish br rounded brown sp dorsal
14	15	2	5	5	0	±165	23	+	brownish yellow an teriorly with zig- brown

l	2	0	+	7	7	2	2	0	+	150–	?
ape	2	0	+	8	9	3-4	3-4	3	+	124–148	46–58
ape	2	0	+	8	9	3	3	3	+	146±	40
al	1	0	+	7	8	1–2	2	0	+	131–139	69–94
al	1	0	+	7	8–7	1–2	2	0	+	150–170	111–134
al	2	0	+	7	8	2	2	0	+	173–179±	83–92
al	2	0	+	7	9	2	2	0	+	172–190	89–110
al	2	0	+	8	11	1	2	0	+	200–235	65–79
l	2	0	+	8	13	1	2–3	0	+	231–239	76–85
al	2	0	+	8	10	1	2	0	+	194–211	.....
l	2	0	+	8	11–13	1–2	2–5	.....	0	209–228	51–60
d	2	0	+	7	9–10	1	2	0	0	199–207	43–47
l	2	0	+	7	7–10	1	2	0	0	200–224	41–52
l	2	0	+	7	9(8–10)	1	2	0	0	199–216	41–53
l	2	0	+	7	9	1	2	0	0	180–213	29–54
l	2	0	+	7	9	1	2	0	0	180–215	43–54
l	1	0	+	8	10–12	1	2	2–3	+	±144	±65
	1	0	+	7–8	10	2	2	0	+	156–173	54–6
l	1	0	+	6	7	1	2	0	+	131–133	52–6
l	1	0	+	8	10–11	1	2–3	0	+	130–150	40–8
l	1	0	+	7–8	9–10	2	2	0	+	140–149	64–8
	1	0	+	7	10	1	3	0	+	135–155	40–8
l	1	0	+	7	10	1	3	0	+	145–155	64–8
l	2	0	0	7	7	1	1–2	0	+	120–128	48–6
	2	0	0	6–7	7	2	2	0	+	117–128	43–5
	2	0	+	6	6	0	2±	0	+	120–125	25
	2	0	+	5	6	0	1	0	+	119–130	25–4
	1	0	+	6-7	5–7	1	2	0	0	138–150	
	2	0	+	7–8	8	1	3	0	0	150–160	65–
	2	0	+	8	8	1	3	0	0	170–180	100–1
	2	0	+	7	8	1	3	0	0	±157	115–1
	2	0	+	7	8	1	3	0	0	140–170	60–
	2	0	+	7	10	1	3	0	0	146–170	66–
	2	+	+	8	10	3	4–6	2–3	0	±150	±4
	2	+	+	7–8	10	3	3	0	0	±136	±4
	2	+	+	12–13	12–13	2	4	4	0	137–143	
	2	+	+	14	15	2	5	5	0	±165	

		ring	spots in single median row or irregular
?	0	light brownish olive; yellow neck band	light in old, dark in young
46–58	0	20–31 light median spots on brown; lateral spots smaller	yellowish more or less blotched with black
40±	0	about 35 dorsal blotches and 2 or 3 lateral rows	greenish white
69–94	0	uniform pale green	greenish white
1–134	0	uniformly pale green	
83–92±	0	solid blue-black, young with spots	white to slate
9–110	0	uniformly greenish blue	greenish to pale yellow
65–79	0	27-40 reddish dorsal blotches	yellowish checked with black
76–85	0	uniform black or gray with black blotches	straw with square or elongate black blotches
.....	0	31–38 dorsal blotches on light brown	yellow with dark spots
51–60	0	40–60 square dark dorsal blotches on yellow	whitish with large black blotches
43–47	0	46–78 dorsal blotches with ant. and post. margins concave	checkered or with only ends of ventrals mottled
41–52	0	yellow spot on each dorsal scale	yellowish with large dark blotches
41–53	0	chiefly black; 50-90 very narrow yellow cross lines	gray with white spots
29–54	0	35–60 dorsal saddles	checkered black and white or suffused with red
43–54	0	23–35 dorsal saddles	checkered with square blotches
±65	0	brown obscurely marked with black	yellow to brown with black dot on each scute
54–65	0	brown with median and lateral pale stripes	yellowish with median stripe
52–65	0	brown with black spots, no stripes	brick red
40–80	0	26–33 dorsal spots on brown	blotched with black
64–81	0	brown; median scales and 5th row with dark stripe; light lateral stripe	yellow with two longitudinal stripes of brown
40–80	0	lateral spots not alt. with dorsal as far forward as head	numerous black edged half circles
64–85	0	uniform dark or reddish brown	uniform light or reddish, some with dark markings
48–60	0	grayish and chestnut with light median stripe and lateral spots	pinkish white
43–52	0	olive to chestnut; 3 pale occipital spots	reddish, without spots
25	0	uniform bluish black	yellowish white
25–46	0	grayish or reddish brown, chestnut parietal band	yellowish or reddish brown
26	0	grayish brown; light mid-dorsal stripe	transverse black spot on each plate
65–75	0	median and lateral stripes (on rows 3+4); black spots between stripes	greenish, black spots near edges
100–108	0	dark brown or black with median and lateral stripes (on rows 3+4)	without spots
115–118	0	light brown with yellow stripes median and on rows 3+4	greenish white
60–80	0	olive brown to dark; yellow or green median and lateral stripes (on rows 2+3)	greenish with black spots
66–95	0	stripes on rows 2+3; skin between dark spots, orange to red.	grayish, greenish or bluish
±45	0	light brown; inverted Y-shaped brown marks on each side	yellowish with black blotches on each scale
±45	0	brown or blackish with about 11 transverse black bands	numerous black blotches; black posteriorly
28	+	gray to blackish brown; 3 series rounded brown spots, about 40 dorsal	thickly blotched with black, paler anteriorly
23	+	brownish yellow and black, posteriorly with zig-zag bands of brown	yellow; blotched and speckled with black at sides

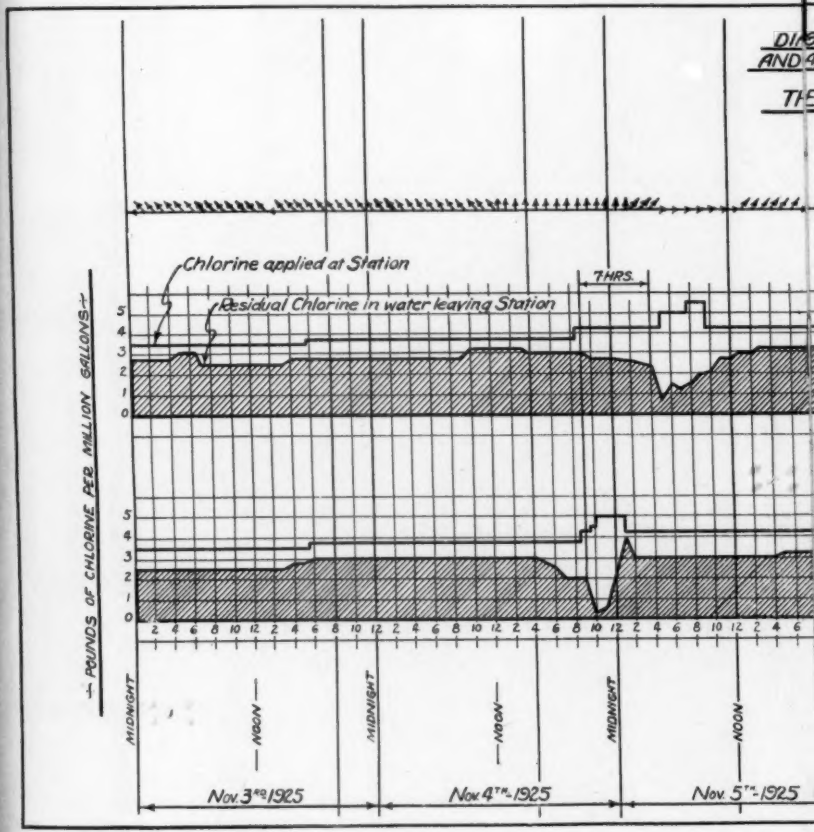
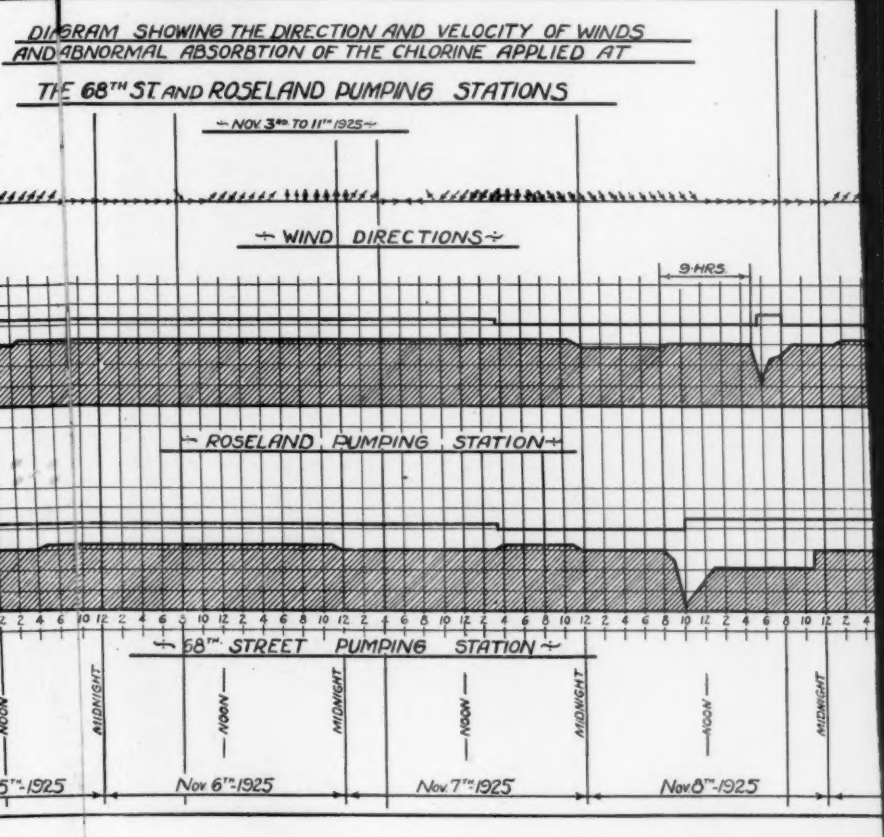
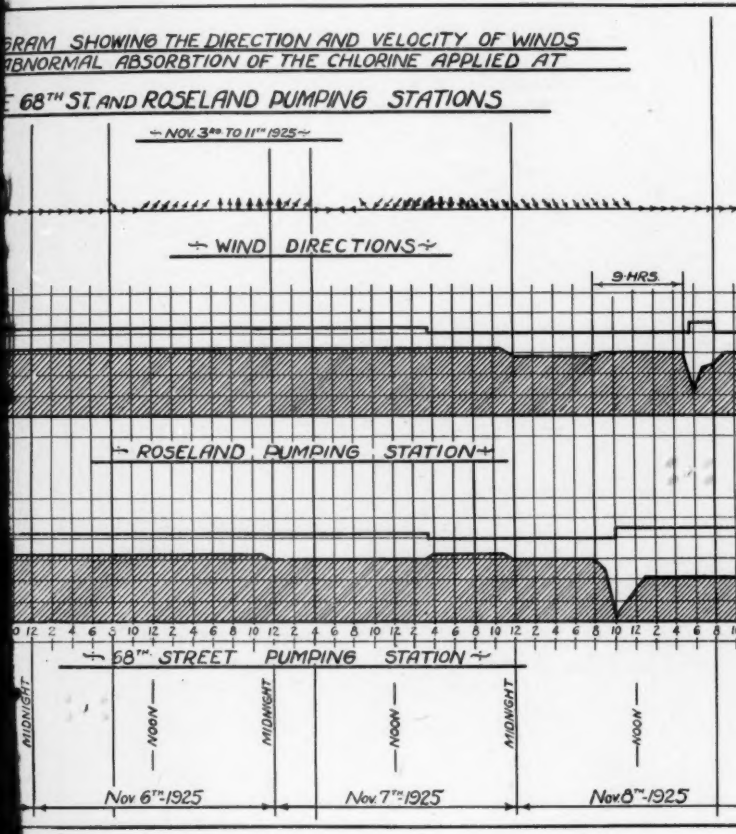
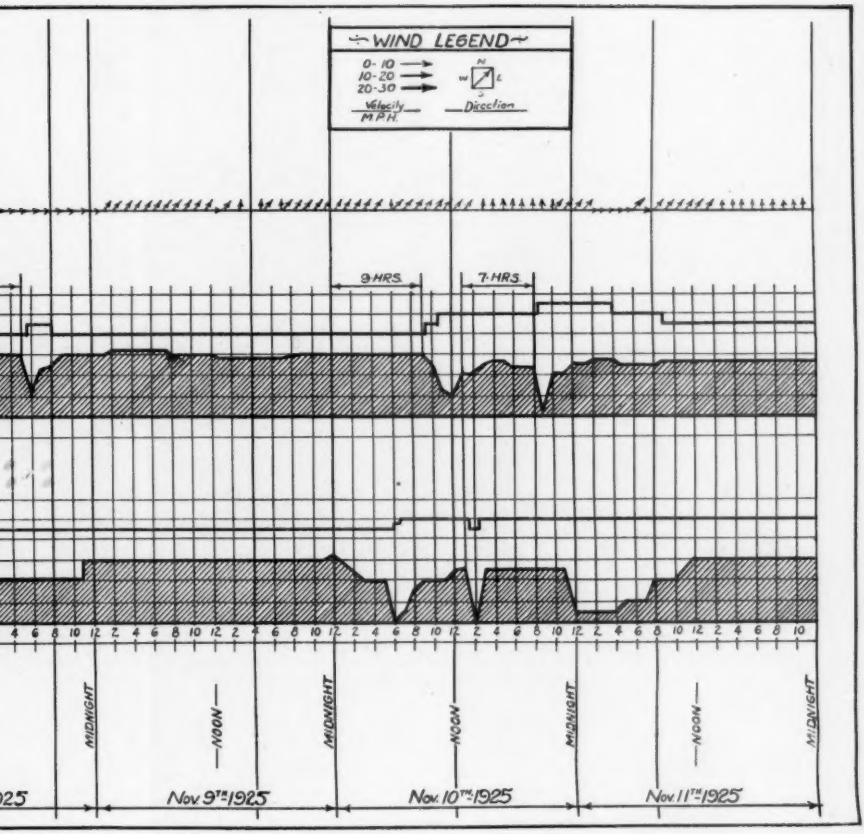

DIA
AND
TH
Chlorine applied at Station
Residual Chlorine in water leaving Station
7 HRS.
POUNDS OF CHLORINE PER MILLION GALLONS
0
1
2
3
4
5
2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6
MIDNIGHT
NOON
MIDNIGHT
NOON
MIDNIGHT
NOON
Nov. 3rd 1925
Nov. 4th - 1925
Nov. 5th - 1925

DIAGRAM SHOWING THE DIRECTION AND VELOCITY OF WINDS AND ABNORMAL ABSORBTION OF THE CHLORINE APPLIED AT THE 68TH ST. AND ROSELAND PUMPING STATIONS




GRAM SHOWING THE DIRECTION AND VELOCITY OF WINDS
ABNORMAL ABSORBTION OF THE CHLORINE APPLIED AT
E 68TH ST. AND ROSELAND PUMPING STATIONS
NOV. 3RD TO 11TH 1925
WIND DIRECTIONS
9 HRS.
ROSELAND PUMPING STATION
68TH STREET PUMPING STATION
MIDNIGHT
NOON
MIDNIGHT
NOON
MIDNIGHT
NOON
Nov 6TH 1925
Nov. 7TH 1925
Nov 8TH 1925


WIND LEGEND
0-10
10-20
20-30
Velocity M.P.H.
Direction
N
W
E
9 HRS.
7 HRS.
4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6 8 10
MIDNIGHT
NOON
MIDNIGHT
NOON
MIDNIGHT
NOON
MIDNIGHT
925
Nov 9TH 1925
Nov. 10TH 1925
Nov 11TH 1925